CENTRAL TIRE INFLATION TRIALS

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CENTRAL TIRE INFLATION TRIALS

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EXECUTIVE SUMMARY

This report presents an analysis of the data collected during two field trials using Central Tire Inflation (CTI) Technology. The first field trial was conducted in the Rural Municipality of Walpole near Wawota, Saskatchewan in the fall of 1999. The second more extensive trial was conducted in the Rural Municipality of Big Quill near Dafoe, Saskatchewan in 2000.

The Walpole trial was planned to have four phases, however, only the first phase was completed and the second phase started before some of the loop roads became impassible. The two phases that were conducted consisted of: (a) running 240 passes of low tire pressure and high tire pressure unloaded trucks on the test road to monitor washboard build-up and, (b) running 420 passes of loaded trucks to determine differences in road maintenance and damage under loaded conditions with low tire pressure and high tire pressure. At the termination of the Walpole trial, no significant damage was noted on the test road which carried high tire pressure and low tire pressure in a side-by-side comparison. However, strength measurements on the two lanes indicated that the high tire pressure lane appeared to be losing strength (increasing deflection) more than the low tire pressure lane. Based on these results, a second more extensive trial was planned for 2000.

The Big Quill trials were conducted near Dafoe and consisted of four trial loops. Each pair of loops included a common centre roadway that would carry vehicles with low tire pressure southbound and vehicles with high tire pressure northbound. This centre roadway was primarily a gravel roadway but a trial section of a TMS surface was constructed to determine the effect of a haul on this surface type. One pair of loops (Loops 1 and 2) carried identical vehicles loaded to the weight permitted on primary highways. The second pair of loops (Loops 3 and 4) carried vehicles loaded to weight permitted on primary highways and low tire pressure southbound and a different fleet of vehicles loaded to secondary highway weight with high tire pressure northbound. However, the intent was to traffic the lanes in a manner to keep the total payload in each lane approximately equal.

On Loops 1 and 2 the high tire pressure trucks made 200 passes on the roadway before the road was deemed impassible. The low tire pressure trucks made 721 passes and the roadway was still considered to be passable. The ruts and failures were less severe in the low pressure lane. It was noted that the section of TMS surface failed completely early in the trials while the gravel surface lasted longer with less severe failures. Some areas of gravel surface showed little deterioration.

On Loops 3 and 4 surface break-up occurred very soon after the start of haul in the high tire pressure lane and continual maintenance was required to maintain truck traffic. In general the total payload was kept equal on the two lanes throughout most of the trial until the high tire pressure lane was considered impassible (13,634t payload). The low tire pressure trucks continued to operate until 17,970t payload had been carried. As for Loops 1 and 2 the TMS surface was the first to fail.

Based on visual observations, the low tire pressure lane carried significantly more payload than the high tire pressure lane with less observed damage for both side-by-side comparison roadways.

An analysis of the common test roads has indicated that, while strength variation was noted, on average the side-by-side comparison lanes had only minor strength differences that may affect the impartiality of the results observed. However, the magnitude of the strength difference is not considered to be significant when compared to the large performance difference noted.

A review of the Dynamic Cone Penetrometer (DCP) results showed that the material in the subgrade was not significantly different at the end of the trials (failed condition) than was noted at the start of the trials (unfailed condition). This observation indicates that the DCP test is not suitable to measure the changes that occur during trafficking.

Benkelman Beam tests were analyzed for each test road. It was noted that the Benkelman Beam tests apparently showed a large increase in deflection shortly after the start of trafficking. However, the deflections measured varied considerably after this large increase .

Modeling of the deflections using static models such as DAMA and ELSYM5 showed that the increase in deflection could not be a result of crust breakdown only. A secondary mechanism of pore pressure build-up was provided to explain the large deflection increase noted during the trials. Applying soil mechanics principles (i.e. pore pressure dissipation is a result of permeability and time), some of the fluctuations in deflections could be explained.

It was concluded that low tire pressure was an effective method to control damage on gravel roadways in a concentrated haul situation. Further conclusions regarding use of low tire pressure are provided in Section 8.0 and Section 9.0 of this report.

1.0 INTRODUCTION

Saskatchewan Highways and Transportation (SHT) and their partners have conducted two trials using Central Tire Inflation (CTI) Technology. The first trial was conducted in the fall of 1999 in the Rural Municipality of Walpole. The second, more extensive trial, was conducted in the summer of 2000 in the Rural Municipality of Big Quill. EBA Engineering Consultants Ltd. (EBA) has been commissioned to review and analyze the data obtained from the two trials and provide an interpretation of the results.

Specifically, EBA was requested to comment on the importance of the conclusions relative to the following considerations.

1. How applicable is low tire pressure for the various road standards that exist in Saskatchewan? i.e. pavements, thin membrane surfaces, super grids, grids, main farm access, municipals roads, basic access roads and prairie trails.

2. How effective is low tire pressure as a damage mitigating measure on all of the various road standards as compared to other factors that could be employed such as reduced vehicle speed and lower axle and gross vehicle weights?

3. On the assumption that road damage can occur very quickly, what measures should road authorities employ to manage their road infrastructure to cope with the significant problems associated with the dramatic increase in trucking activity related to agriculture?

4. If possible, quantify the potential benefit of introducing reduced tire pressures at the existing weight regulations.

The following sections provide a summary of the objectives of each of the two trial projects and the conclusions that were derived by Saskatchewan Highways.

1.1 Walpole Trial

The Walpole trial was conducted in the fall of 1999 (i.e. road conditions were strong) on roadways located just west of the Town of Wawota in the Rural Municipality of Walpole. Figure 1-1 shows the arrangement of the roadways. Grid Road 601 was the 'test road' with trucks with high tire pressure, also referred to as normal highway tire pressure, travelling

south and trucks with low tire pressure, also referred to as optimized or reduced tire pressure, travelling north. Other roads used by the trucks are referred to as loop roads.

The following four phases were planned for the trial, however, Phases III and IV were not completed:

Phase I
- Trafficking with unloaded trucks to demonstrate differences in washboard development with normal and reduced tire pressures on the two lane Primary Grid Road (Grid 601).

Phase II
- Trafficking with trucks with different tire pressures loaded to the same axle loads to demonstrate differences in road damage and maintenance.

Phase III
- To demonstrate differences in road damage using seven identical trucks operating at primary axle weights and optimized tire pressures versus eleven trucks operating at secondary axle weights and normal highway tire pressures hauling the same total payload of grain.

Phase IV
- A repeat of Phase III but with wet roadbed material on a portion of Grid 601.

The stated objective of this field trial was to demonstrate the difference in road impacts between trucks operated with optimized tire inflation pressures versus identical trucks operated with normal highway tire inflation pressures.

The empty trucks in Phase I had a total weight of 23,400 kg which was carried as follows:

Steering Axle	5,030 kg
Drive Tandem Axle	6,050 kg
First Trailer Triple Axle	6,480 kg
Final Trailer Triple Axle	5,840 kg

For the high tire pressure trials, all tires were inflated to 100 psi. For the low tire pressure trials the front steering axle was maintained at 100 psi while all other tires were reduced to 30 psi. A total of 240 truck passes at each pressure were applied to the test road.

Figure 1-2 shows the results of Phase I of the trial (washboard development). The washboard development was more widespread and more severe in the high tire pressure lane.

Phase II consisted of trafficking with loaded trucks with high and low tire pressures to demonstrate differences in road damage and maintenance. The loaded trucks had a total gross vehicle weight of 70,500 kg with the steering axle loaded to 5,500 kg, tandem drive axle loaded to 17,000 kg, and each of the triple trailer axle loaded to 24,000 kg. For the high tire pressure trucks, all tires were inflated to 100 psi. For the low tire pressure trials the front steering axle was left at 100 psi, the tandem drive axle tires were reduced to 65 psi and the trailer axle tires were reduced to 60 psi.

The loaded trucks made approximately 420 passes in each lane before the trial was suspended due to failures on the loop roads.

During the trials, Benkelman Beam deflections were measured on the two lanes before and after trafficking. Figure 1-3 shows the relationship between the low and high tire pressure lanes. It is apparent that the deflection increased more on the high tire pressure lane than for the lower pressure lane.

To explain the increase in deflection, SHT has proposed a crust breakdown theory which is presented in Figures 1-4 and 1-5. This theory proposes that a cracked clay cap does not provide the same level of support as an intact clay cap and therefore as the traffic breaks the clay cap, the layer becomes weaker and the deflection increases.

In addition to the measurements conducted on Grid Road 601 where a side by side comparison was provided, SHT also conducted rut and cracking surveys on a section of TMS (Thin Membrane Surface) surface on Highway 48. One of the difficulties with the trial was that the trucks travelled on different portions of the highway with low tire pressure east of the Grid Road 601 intersection and high tire pressure west of the Grid Road 601 intersection. Therefore, the following conclusions may be as a result of differences in structure or subgrade rather than as a result of the traffic difference.

The TMS structure of Highway 48 developed considerable surface damage (cracking, potholing, and push out features) in response to trafficking. This surface damage was observed to be of a more severe nature in the high tire pressure portion of the roadway than in the optimized tire pressure portion of the roadway. However, the TMS showed little structural deterioration, as indicated by a lack of change in deflection measurement with trafficking. The high tire pressure section deflected an average of 1.78 mm before trafficking and 1.76 mm after trafficking. The average deflection for the low tire pressure section, before and after trafficking, remained the same at 1.82 mm.

Figure 1-6 shows the change in rutting before and after trafficking. Figure 1-7 shows the change in surface damage.

Based on the average deflection of Grid Road 601, SHT felt that 411 passes of the high tire pressure trucks created more damage than 428 passes of the low tire pressure trucks. However, the number of passes of low tire pressure that would cause the same damage as 428 passes of high tire pressure was unknown. This concept is presented in Figure 1-8. The second trial at Big Quill was designed to provide answers to this question.

1.2 Big Quill Trial

The Big Quill trial was conducted on roadways located near the Town of Dafoe in the Rural Municipality of Big Quill. The test was conducted in late July 2000. Figure 1-9 shows the arrangement of the roadways.

Two distinctly different trials were conducted on these roadways. Loop 1 carried trucks loaded to permitted weight for primary highways with low tire pressures. The gross load was 70,500 kg with 5500 kg on steering axle, 17,000 kg on tandem drive axle and 24,000 kg on each of the triple trailer axles. These vehicles are 9 axle B-trains locally referred to as King Bees. The tire pressure was 80 psi in front tires, 60 psi in drive axle tires and 50 psi in trailer tires. Loop 2 carried exactly the same vehicles with high tire pressures. The gross truck weight and axle weights on Loop 2 were equal to Loop 1 with all tires set to 100 psi. Loop 3 carried trucks loaded to the weight permitted for primary highways with low tire pressures. The gross truck weights and tire pressures were identical to Loop 1. Loop 4 carried 6 axle and 8 axle B-train trucks loaded to secondary highway weights with high tire pressures. The gross truck weight varied by truck type with 6 axle trucks at 40,000 kg and 8 axle B-trains at 54,500 kg. Front steering axles carried 5,500 kg, tandem axles carried 14,500 kg and triple axles carried 20,000 kg. All tires were inflated to 100 psi.

In each case the common road (Road 103 and 202) carried low tire pressure traffic southbound and high tire pressure traffic northbound. On the equal axle weight trial (Loops 1 and 2) a total of 200 passes of the high tire pressure vehicles and 721 low tire pressure vehicles were applied.

On the equal payload trial (Loops 3 and 4) a total of 380 low tire pressure passes (17,970t payload) and 478 high tire pressure passes (13,634t payload) were applied.

The stated objectives of the Big Quill trials were to determine if significant damage reduction resulted when the tire pressure was reduced and to determine if lower tire pressures could cancel the damage caused by carrying primary highway weights on secondary weight roads.

Figure 1-10 shows the relationship between deflection (as measured by the Benkelman Beam) and payload for Test Road 103. It can be seen that the deflection in the lane carrying the high tire pressure loads increased rapidly after the start of haul and then increased at a slower rate until the road was virtually impassable at 9350 tonnes (200 passes). The deflections in the low tire pressure lane also increased considerably shortly after the start of haul and then showed an erratic pattern of higher and lower deflections until the trial was halted at a total payload of 33,725 tonnes (721 passes). The deflection in the low tire pressure lane never reached the same magnitude as the high tire pressure lane and even after 33,725 tonnes of payload the low tire pressure lane was still passable.

Figure 1-11 and Figure 1-12 show the development of failures in the gravel and TMS surfaces as related to total payload for Test Road 103. The length of road shown as failed does not differentiate between deep failures and shallow failures and therefore may not indicate the total difference between the two lanes.

Figure 1-13 shows the deflection versus payload for Test Road 202. Figures 1-14 and 1-15 show the cumulative length of failure versus payload hauled for both the gravel and TMS surfaces on Test Road 202. For this test road, continual maintenance was required, especially on the high tire pressure lane, to restore cross-section to maintain traffic flow. The length repaired for that portion of the road was still considered as a failed section in Figures 1-14 and 1-15.

These preliminary results from the Big Quill Trials indicate that low tire pressure caused less damage than high tire pressure. Based on the equal axle weights trial (Test Road 103) the low tire pressure lane carried more than three times the payload and traffic volume and had less damage in terms of the percent roadway failed (Figures 1-11 and 1-12). In addition, Benkelman Beam deflections were less at the end of the trial in the low tire pressure lane than at the end of hauling in the high tire pressure lane (Figure 1-10).

Based on the equal payload trial (Test Road 202) the low tire pressure lane carried more payload at the weight permitted on primary highways with less damage than the high tire pressure at secondary axle weights (Figures 1-14 and 1-15). In addition, Benkelman Beam

deflections were about the same or less at the end of the trial in the low tire pressure lane than in the high tire pressure lane (Figure 1-13).

2.0 LITERATURE REVIEW

A previous literature review had been conducted by Allan H. Bradley, RPF, P.Eng, in May 1997, entitled "The Effect of Reduced Tire Inflation Pressures on Road Damage: A Literature Review" Report SR123, Forest Engineering Research Institute of Canada. A list of papers reviewed for this literature study is included in Appendix A of this report. The intent of the EBA literature review was to build upon this previous study and not redo previous work.

In order to build on this previous literature study, the following section is quoted directly from the above noted document.

"Considerable interest over the influence of variable tire pressures on road damage and design criteria has been generated recently with the introduction of commercial central tire inflation system (CTI systems). The Forest Engineering Research Institute of Canada (FERIC) introduced commercial CTI systems to Canada in 1990 and has been active in system development and implementation since that time.

This literature review was initially prepared as background for a current investigation into the optimizing of forest road designs for vehicles employing variable tire pressures (as managed by CTI systems). FERIC expanded its scope to include thawing pavement effects in response to interest from the Canadian forest industry. The objective of this literature review is to summarize the state of knowledge about roads and variable tire inflation pressures, and to make recommendations regarding future research needs.

Reducing the inflation of a conventional radial truck tire to 173-450 kPa (25-65 psi) causes its contact area to increase and its sidewalls to deflect more. As a result of this deformation, the tire experiences less slip and wheel hop, transmit less vertical energy to the road surface, and generates lower vertical contact pressures (especially in the middle of the contact area). Reducing tire pressures has been found to improve ride, traction and mobility; slow rut development and form wide shallow ruts; reduce gravel losses and sediment production; prevent washboard formation and heal existing washboard; reduce grading requirements; and, extend hauling season.

Only one model for low volume forest road design, the USDA Forest Service's Surfacing Thickness Program (STP) Version 1.02, currently incorporates tire inflation pressure as a variable. This model has been verified with rutting measurements gathered in structured tests and in field trials. The STP model predicts that aggregate reductions of 25-30% are possible for typical American forest roads and 18-wheel log truck traffic, if variable tire pressures are used; this prediction has been substantiated in field trials. The STP model predicts 22% slower rutting of earth- and aggregate-surfaced roads, if traffic employs variable tire pressures, and about half this reduction if a constant reduced tire pressure is used. Predictions made for the larger configurations used in western Canada indicate even greater potential improvements.

Fatigue cracking in thin and thick pavements has been investigated using finite element models. These investigations indicate that elevated tire pressures (reduced contact length) can increase the strain felt at the bottom of the wear course significantly; and, the associated damage increases rapidly with inflation pressure. Thus, over-inflation has been found to be a significant factor in pavement fatigue cracking - especially for thinner, flexible pavements. Fatigue cracking is exacerbated by vehicles with less "road friendly" suspension components, such as radial rather than bias ply tires, wide-base single tires rather than dual tire assemblies, or stiff (e.g. rubber block) rather than compliant suspensions (e.g. air bag). The rutting of thin, flexible pavements is influenced less by over-inflation because the higher pavement strains are somewhat compensated for by the shorter time the pavement is exposed to the strain by virtue of the shorter contact patch.
In light of the observed changes in tire damping, wheel hop frequency, and tire stiffness with reduced inflation pressures, it is likely that they are important factors in reducing road damage.

Both operational trials and structured tests have found that lowering tire pressures reduces the damaging impact of trucks on roads, especially on rough roads. The effect of variable pressures on damage in thick pavements has not been well researched, and further study is warranted. Variable tire pressures have been found to have a significant impact on thin pavement damage - in one test, reducing the severity of cracking, and extending pavement life by about two times. Computer modeling of thin pavements predicts that use of variable tire pressures will permit a reduction in base course aggregate thickness in order of 10-12%.

The effect of reducing tire pressures on thawing pavement damage has been the subject of two recent computer analyses. Results from this research have been promising so far, and may lead to the acceptance of CTI systems as a means to mitigate damage to thawing pavements, and thereby provide CTI-equipped trucks with some exemption from highway

weight restriction programs during spring thaw conditions. A full scale trial is currently underway to confirm the predicted benefits, for both thin pavement and a chip sealed surface.

The computer analyses indicated that reducing tire pressures reduces pavement strains and extends thawing pavement life, pavement life will be extended with respect to both fatigue and rutting failure, but the effect is more significant for fatigue cracking; the extent of the improvement depends greatly on the pavement material properties; and, thinner pavements will experience more benefit from reducing tire pressures, especially for tire pressures below 414 kPa (60 psi). With respect to implementing the technology, knowing pavement section stiffness is critical to determining whether to allow heavy vehicle traffic with or without reduced tire pressures or tire load or both. Further, the actual number of load repetitions to failure must be considered when making a decision to permit traffic on a thaw weakened road."

In addition to the above summary, the following papers were also reviewed:

- Raad, Lutfi; Minassian, George; and Saboundjian, Stephans, 1998 'Mechanistic Evaluation of the Effect of Tire Inflation Pressure on Pavement Damage Under Spring Thaw Weakening", TRB Paper 980831.
- Henry, Karen, 2001, 'Influence of Wheel Road Shape on Vertical Stress Reaching Subgrade Through an Aggregate Layer', US Army Corps of Engineers, Engineer Research and Development Centre'.
- Kestler, Maureen; Berg, Richard; Moore, Thomas, 1997, 'Reducing Damage to Low-Volume Roads by Using Trucks with Reduced Tire Pressures' Transportation Research Record 1589.
- Foltz, Randy; Elliot, William; 1997 'Effect of Lowered Tire Pressures on Road Erosion' Transportation Research Record 1589.
- Douglas, Robert; Woodward, W.D.H.; and Woodside, A.R.; 2000 'Road Contact Stresses and Forces Under Tires with Low Inflation Pressure', Canadian Journal of Civil Engineering, p 1248-1258.

In addition several internal SHT papers were reviewed, however most of these papers present research leading up to the trial projects or preliminary results of these trials. Since this report presents a detailed analysis of the field trials the following reports have not been used to provide back-up information.

- Davis, Thomas; Wall, Tami; Carpentier, Allan, 1997 'Saskatchewan Highways and Transportation Reduced Tire Pressure Initiative', Transportation Research Record 1589.
- Bradley, Allan; Stamatinos, George; 2000 'Field Demonstration Comparing Damage to Rural Saskatchewan Roads Caused by Optimized and Normal Highway Truck Tire Pressures', Internal Saskatchewan Highways report.
- Unknown, 1997 'Central Tire Inflation/Constant Reduced Tire Pressure (CTI/CRP) Initiative', Internal Saskatchewan Highways report.

All of these papers reiterate that the low tire pressure results in lower contact pressures and reduced damage to thin pavements or non-surfaced roadways.

3.0 BIAS POTENTIAL EVALUATION

The roadways for the trials were selected on the basis of operational requirements, i.e. availability of nearby loop roads, concurrence of the Rural Municipality, etc. Because the roads were selected basically at random, there may be strength variability between the northbound and southbound lanes. This variability may introduce a bias between the high and the low-pressure lanes of the test roads. The following sections outline an analysis of the available data to determine any bias that may have an influence on the results of the trials.

3.1 Need and Process for Bias Analysis

The CTI study was conducted to evaluate the difference in truck traffic impact on specific roads for trucks with high tire pressure as compared to trucks with low tire pressure. Since this is a comparative study it is important to identify any significant differences in the characteristics of the roads where paired comparisons were to be made.

For the main study routes the trucks with low tire pressure and high tire pressure were separated to specific road lanes by direction of travel. For these study sections the comparative bias identification was to determine if the road characteristics of one lane differed from the characteristics of the adjacent lane.

Prior to any test traffic the road characteristics were determined by soils sampling in the traveled lane. Samples were taken at specific intervals along the road and at specific depth intervals. Atterberg limits, natural moisture content and densities were determined. Dynamic cone penetration, DCP, tests were also conducted at intervals along the test routes

and soil strength profiles with depth to 1,000 mm were obtained in each loaded or trafficked lane. Benkelman beam testing was also conducted and road top cross sections were obtained.

Soils and the roads of which they are constructed are known to be variable. Statistical evaluations were performed on the test data to determine if there was a statistical difference at the 95% confidence level. It was deemed inappropriate to use a lesser confidence level to test for statistically significant differences.

Cross-sections of the road-top were taken along the test routes prior to placing test traffic on the routes. Only a visual comparison of the pre-traffic cross sections was undertaken. The visual review did not note any differences that would bias the experiment.

3.2 Soil Physical Properties

3.2.1 Test Road 103

Along Test Road 103 soil samples were taken at depths of 300 and 600 mm and at 200 m intervals in each lane along the road. Table B-1 in Appendix B has the details on the sample tests. Table 3-1 below is a summary of the soil test data.

The analysis showed that there were no statistical differences in the physical characteristics of the soil at the 95% confidence level at either the 300 mm or the 600 mm depth between the lanes along the road.

Table 3-1 Summary of Soil Properties Comparing High and Low tire pressure lanes for Possible Bias; Road 103, Big Quill

Statistical Summary	Low tire pressure lane Soil Properties					High tire pressure lane Soil Properties			
	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Group Index	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Group Index
Soil Samples from a Depth of 0.3 m									
Mean	12.9	36	16.192	19.808	9.7576	35.515	16.325	19.19	9.7281
Standard Deviation	2.53	4.3445	1.9766	4.8868	2.6343	4.2362	1.9096	4.2938	0.5148
Statistical Difference @ 95% Confidence	No	No	No	No	No	No	No	No	No
Number of Samples	33	33	33	33	33	33	33	33	33
Soil Samples from a Depth of 0.6 m									
Mean	14.723	35.121	17.471	17.65	9.3939	35.636	17.994	17.642	9.303
Standard Deviation	3.525	7.0744	4.0879	4.263	2.4614	4.5057	2.5771	3.8512	2.7213
Statistical Difference @ 95% Confidence	No	No	No	No	No	No	No	No	No
Number of Samples	33	33	33	33	33	33	33	33	33

3.2.2 Test Road 202

Test Road 202 is the second test road at the Big Quill site. This road carried trucks equipped with low tire pressure in the southbound lane and trucks with high tire pressure in the northbound lane.

Soil samples were taken at 300 mm, 600 mm and 1 m depths at 200 m intervals along Test Road 202 in both the southbound and northbound lanes. The test results are detailed on Table B-2 in Appendix B. There were 120 samples taken in each lane.

Table 3-2 provides a summary of the detailed data contained in Appendix B.

Table 3-2 Summary of Soil Characteristics, Route #202

	Left of Centreline, (Low Pressure)							Right of Centreline (High Pressure)						
	Soil Properties				One-Point Proctor Data			Soil Properties				One-Point Proctor Data		
	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Wet Density (kg/m³)	Dry Density (kg/m³)	One-Point Moisture Content (%)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Wet Density (kg/m³)	Dry Density (kg/m³)	One-Point Moisture Content (%)
Number of Tests	120	70	70	70	64	64	64	119	70	70	70	64	64	64
Mean	14.6	32.2	16.5	15.7	2113	1845	14.6	15.6	32.3	16.7	15.6	2090	1827	14.5
Standard Dev.	4.4	3.9	2.5	3.2	85.7	104.9	2.3	5.1	4.0	3.1	3.5	97.7	103.3	1.8
Statistical Diff.	No	No	No	No	No	No	No	No	No	No	No	No	No	No

An analysis of the test data indicates that, at the 95% confidence level, there was no significant difference between the soil physical properties comparing the high and low tire pressure lanes.

There is no bias between comparison lanes due to soil properties

3.2.3 Grid Road 601

Grid Road 601 is the primary test road in the RM of Walpole part of the trials. The southbound lanes carried the trucks with high tire pressure while the northbound lanes carried the trucks with low tire pressure. Soil samples were taken along this road in both lanes from km 6 to km 11. Again the basic soil properties were determined.

Table 3-3 shows this test data. At the 95% confidence level there is not a significant difference between lanes.

Table 3-3: Soils Characteristics Grid Road 601 for North, (LP), & South, (HP), Bound Lanes

South Bound, (High Pressure)							North Bound, (Low Pressure)						
STATION	W_L	W_P	N_W	P.I.	G.I.	CBR	STATION	W_L	W_P	N_W	P.I.	G.I.	CBR
6.1	37.6%	15.2%	14.2%	22.4	8.8	5.3	6.6	38.8%	14.3%	14.0%	24.5	9.8	4.9
7.1	34.7%	15.1%	11.2%	19.6	7.7	5.7	7.6	38.6%	15.7%	16.6%	22.8	9.6	5
8.1	39.4%	17.3%	19.7%	22.1	9.6	5	8.6	36.8%	14.7%	15.2%	22.1	9	5.2
9.1	35.7%	15.4%	14.4%	20.3	5.6	7	9.6	37.9%	15.4%	14.5%	22.5	9.4	5
10.1	38.4%	15.5%	16.8%	22.9	9.8	4.9	10.6	32.3%	13.4%	13.9%	18.8	7.8	5.7
11.1	34.6%	13.8%	12.2%	20.8	7.9	5.6							
Stat Dif @ 95% Conf. Level	No	No	No	No	No	No		No	No	No	No	No	No
Ave.	36.7%	15.4%	14.8%	21.4	8.2	5.6		36.9%	14.7%	14.8%	22.14	9.12	5.16
Std Dev	2.0%	1.1%	3.1%	1.3	1.5	0.8		2.7%	0.9%	1.1%	2.08	0.79	0.32

3.3 Dynamic Cone Penetration (DCP) Tests

Extensive DCP tests were carried out on each lane of the test roads prior to the commencement of the truck traffic. The cone was driven to a depth of 1 m. Blows per mm penetration at 25 mm increments for the upper 400 mm and then at 50 mm intervals for the lower 600 mm were extracted from each DCP profile.

Tables B-3 to B-5 in Appendix B summarize the extensive DCP data. All tests shown are pre-traffic tests. The information from these tables has been shown on Figures 3-1 to 3-3.

Statistical analyses were carried out comparing the two lanes penetration per blow along the section of road at comparable depths. This was done to determine if there was a statistically significant difference in cone penetration per blow between comparable high and low tire pressure lanes.

3.3.1 Pre-Trial DCP for Test Road 103

Table B-3 in Appendix B shows the DCP test data for Test Road 103. The same information is included in Figure 3-1.

The northbound lane of Test Road 103 carries the high tire pressures while the southbound lane carries the low tire pressures. Testing was carried out on an extension of Test Road 103 to the south of Loop Road 105. This extension to the south was not part of the test road. It was interesting to note that that the road to the south of test road was significantly weaker at depth than test segment 103.

There was no significant statistical difference in DCP measurements between the test lanes of Road 103 at the 95% confidence level.

3.3.2 Pre-Traffic DCP Test for Road 202

Pre-trial DCP tests were taken on Test Road 202 and for 1.6 km south of the test segment, south of Loop Road 206. It is interesting to note that in the section of road lying to the south of Loop Road 206 the northbound lanes were significantly weaker than the southbound lanes, however this segment is not in the trial.

Within the test section there was a statistical difference at the 96% confidence level for the DCP values between the 25mm and the 75 mm level with the southbound lane, which carried the low tire pressures, being the stronger lane.

Below the 75 mm level there was no statistically significant differences at the 95% confidence level.

The DCP test data for Test Road 202 is shown in Table B-4 in Appendix B and Figure 3-2.

3.3.3 Pre-Trial DCP for Grid Road 601

Grid Road 601 is the Test Road at the Walpole test site. The northbound lanes carry the low tire pressure traffic while the southbound lanes carry the high tire pressure truck traffic. The DCP testing was extended to the south of the test site but was not trafficked in the trial.

At the 500 mm and the 700 mm depths the southbound or high tire pressure lane is significantly stronger at the 95% confidence level. The DCP penetration is about 5 mm per blow greater in the low tire pressure lane than in the high tire pressure lane. At depths less than 500 mm or greater than 700 mm there is no significant differences in the DCP strength measurements between lanes.

The DCP data for Grid Road 601 is shown in Table B-5 in Appendix B and Figure 3-3.

3.3.4 Pre-Trial Benkelman Beam Deflection Testing on the Test Roads

Table 3-4 shows the pre-trial Benkelman beam deflection tests. Testing was carried out at 400 m spacing in each lane except in the areas of the thin membrane surfacing (TMS) where the test frequency was increased to 100 m spacing.

Comparing the pre-trial test data for Test Road 103, the southbound lane carrying the low tire pressure traffic has an average deflection of 1.99 mm while the northbound lane, carrying the high tire pressure traffic, has a deflection of 1.94 mm. A statistical comparison of the deflections in the northbound (high tire pressure) and southbound (low tire pressure) lane indicate there is no statistical difference in Benkelman beam deflections at the 95% confidence level.

Test Road 202 has the high tire pressure traffic in the northbound lane with the low tire pressure traffic in the southbound lane. The overall deflections for the 8 km test segment shows the average deflections are similar. It is noted that the cold mix asphalt mat was relatively new. With July temperatures this cold mix layer would have a low stiffness which one would expect to result in higher deflections. This is reflected in the cold mix deflections being 0.6 mm and 0.8 mm higher than the section as a whole. Statistical analysis of all of the deflection tests in both the cold mix section and the test section as a whole indicated that there was no statistical difference between the northbound and the southbound lanes at the 95% confidence level.

Grid Road 601 is the test road at the RM of Walpole site. Benkelman beam deflection tests were taken in both lanes on September 23, 1999 prior to the commencement of the test truck traffic. Deflections were measured at 400 m intervals in each lane from km 6 to km 11. Each deflection site was offset by 200 m, i.e., the beam test sites were staggered along the test section. The locations are shown in Table 3-4.

At the 95% confidence level there was no statistical difference between the northbound and the southbound lanes.

3.4 Summary

Table 3.5 is a summary of the findings of the bias assessment for the various physical attributes comparing the lanes carrying the high tire pressure traffic to those carrying low tire pressure traffic.

The only statistical differences at the 95% confidence level noted in properties were in the dynamic cone penetration data and then only at specific soil horizons. The DCP data showed a difference at specific discrete depths on 2 of the test roads. This bias favored the low tire pressure on one road and the high tire pressures on the another road with a third road showing no DCP bias.

Table 3-4 Benkelman Beam Deflections Prior to Carrying any Traffic

Test Road 103 Northbound Lanes (High tire pressure)		Test Road 103 Southbound Lanes (Low tire pressure)		Test Road 202 Northbound Lane (High tire pressure)		Test Road 202 TMS Section Northbound Lane (High tire pressure		Test Road 202 TMS Section Southbound Lane (Low tire pressure)		Test Road 202 TMS Section Southbound Lane (Low tire pressure)	
STATION BY km	BB DEFLECTION, mm	STATION BY km	BB DEFLECTION, mm	STATION BY km	BB DEFLECTION, mm	STATION BY km	BB DEFLECTION, mm	STATION BY km	BB DEFLECTION, mm	STATION BY km	BB DEFLECTION, mm
0.000	NR	0.000	NR	0.000	NR			0.000	NR		
0.400	2.88	0.400	1.48	0.400	3.32			0.400	3.12		
0.800	3.00	0.800	1.36	0.800	3.52			0.800	5.68		
1.200	2.40	1.200	1.32	1.200	4.60			1.200	3.44		
1.600	2.72	1.600	3	1.600	1.64			1.600	1.68		
2.000	2.88	2.000	2.16	2.000	1.08			2.000	1.36		
2.400	3.92	2.400	3.72	2.400	1.28			2.400	1.52		
2.800	1.96	2.800	1.32	2.800	2.16			2.800	1.60		
3.200	3.72	3.200	3.6	3.200	1.72			3.200	2.16		
3.600	3.16	3.600	2.76	3.600	1.84			3.600	2.00		
4.000	2.92	4.000	2.4	4.000	2.24	4.800	2.40	4.000	2.28	4.800	2.48
4.400	3.56	4.400	1.48	4.400	1.68	4.900	2.40	4.400	1.88	4.900	2.08
4.800	1.44	4.800	1.44	4.800	2.40	5.000	2.44	4.800	2.48	5.000	1.96
5.200	1.76	5.200	1.48	5.200	2.96	5.100	2.24	5.200	4.32	5.100	2.4
5.600	2.32	5.600	1.8	5.600	2.60	5.200	2.96	5.600	2.56	5.200	4.32
6.000	2.52	6.000	1.4	6.000	2.00	5.300	2.96	6.000	2.12	5.300	3.76
6.400	2.92	6.400	1.12	6.400	2.04	5.400	2.96	6.400	2.56	5.400	5.4
				6.800	2.40	5.500	3.88	6.800	1.64	5.500	3.92
				7.200	2.96	5.600	3.60	7.200	2.32	5.600	2.56
				7.600	1.24	5.700	2.56	7.600	1.20	5.700	1.96
				8.000	1.08			8.000	1.24		
AVERAGE	2.76		1.99		2.238		2.84		2.36		3.21
STD. DEV.	0.68		0.85		0.90		0.55		1.10		1.19

Table 3-4 Benkelman Beam Deflections Prior to Carrying any Traffic (cont.,)

Grid Road 601, June 1999 Northbound (Low tire pressure)		Grid Road 601 June 1999 Southbound (High tire pressure	
STATION BY km	BB DEFLECTION, mm	STATION BY km	BB DEFLECTION, mm
0.400	4.36	0.200	0.96
0.800	1.96	0.600	1.40
1.200	4.56	1.000	0.88
1.600	2.00	1.400	2.20
2.000	4.64	1.800	1.60
2.400	3.76	2.200	0.88
2.800	3.68	2.600	1.16
3.200	2.00	3.000	1.24
3.600	2.84	3.400	1.16
4.000	3.04	3.800	0.80
4.400	4.32	4.200	0.96
4.800	2.84	4.600	1.40
5.200	3.44	5.000	1.24
5.600	3.64	5.400	1.68
6.000	3.12	5.800	1.20
6.400	4.00	6.200	0.96
6.800	2.96	6.600	1.36
7.200	4.04	7.000	0.96
7.600	2.68	7.400	1.52
8.000	2.60	7.800	2.84
8.400	1.08	8.200	2.64
8.800	3.60	8.600	3.68
9.200	2.60	9.000	3.80
9.600	2.64	9.400	4.00
10.000	2.00	9.800	3.12
10.400	1.84	10.200	4.68
10.800	3.52	10.600	2.44
11.200	2.24	11.000	2.76
	3.071		1.911
	0.93		1.11

Table 3-5 Summary of Road Characteristics that Might Form a Bias

Test Road Number	Road Physical Attribute	Possible Bias	Lane Favoured HP or LP
All Roads	Soil Characteristics	No Bias	
All Roads	Road Top X-Section	No Bias	
Test Road 103	DCP	No Bias	
Test Road 202	DCP	*Slight Bias	LP
Test Grid Road 601	DCP	*Slight Bias	HP
Test Road #103	BB Deflection	No Bias	
Test Road # 202	BB Deflection	No Bias	
Test Grid Road #601	BB Deflection	No Bias	

* Slight Bias is used to indicate that a statistical difference was only found at some soil horizons on two test roads and neither on all roads nor all horizons.

It is our opinion that the above two slight bias indicators are insignificant in the overall analysis of the test roads.

4.0 ANALYSIS OF TESTING CONDUCTED

SHT and their partners conducted several different strength measurements and performance measurements on the roadways before, during and after the trials.

Strength measurements consisted of soil testing before trafficking, Dynamic Cone Penetrometer (DCP) tests, and Benkelman Beam rebound deflections. Performance measurements consisted of rut measurement at discrete locations and continuous visual observations which were documented by regular video footage. Other tests, such as nuclear densometer measurement of moisture content and density before and after trafficking were also conducted.

Also in conjunction with the main roadway performance trials other studies such as gravel kick-off and effect of speed on gravel loss, and Benkelman Beam tests using various tire pressures and trucks to apply the loads were also studied. However, these other studies are not included in this report.

The following sections summarize the DCP and Benkelman Beam measurements. The sections focus on the test roads only presenting results of comparative, by lane, analysis of the measurements.

4.1 Dynamic Cone Penetrometer Tests - Bill Quill Test Site

DCP tests were carried out on the two test roads (Test Roads 103 and 202) and on each of gravel surface roads forming the loops of the trial. The tests were conducted prior to and during the trial on each of the roadways and following the trial on Test Roads 103 and 202. Pre-and post measurements were carried out to a depth 1000 mm and during trial tests to 500 mm.

The following summarizes the DCP measurements and focusing on the test roads, presents results of comparative, by lane, analyses of the measurements.

Prior to performing the summary, the DCP files were transposed from tabular to column format from which mm/blow with depth values could be readily calculated. An initial review of a sample of the DCP profiles indicated that changes in DCP values were frequent in the upper layers to a maximum depth in the 200 to 400 mm range. Commencing at the surface to 400 mm, mm/blow values at 25 mm increments were extracted from each DCP test carried out prior to and after the trial. At depths exceeding 400 mm the increment was increased to 50 mm.

4.1.1 Test Road 103 DCP Measurements

DCP tests on Road 103 were conducted prior to and following the trial and at selected sites during the trial.

Commencing 1.6 kms south of the test road segment, (1.6 kms south of Junction Road 105), a total of 64 pre-trial DCP tests were carried out on July 12, 2000. Tests were in both lanes, at 1.8 m centreline offsets, and 200 m spacings.

Post-trial tests were conducted August 2, 2000 at 2.4 to 2.8 m offsets. The spacing between tests within the initial (southern most) 1.6 kms was increased from 200 to 400 m.

The matrix of during-trial DCP testing is summarized in Table 4-1. Tests included both lanes at 5 stations with the number of tests on a given date and location varying from 1 to 3. All tests were conducted in the outer wheelpath with the spacing between consecutive tests at a given station equal to 0.5 m. That is, the tests encompassed a range of approximately ±2 m from the noted stations. All during-trial tests were carried out to a depth of 500 mm.

Table 4-1 During-Traffic DCP Tests – Road 103

Station	Lane	26-Jul	27-Jul	28-Jul	29-Jul	30-Jul	31-Jul	1-Aug
2+198	NBL			2				
	SBL	1	1		2	3	3	1
3+398	NBL	1		2				
	SBL		2		2	3	3	1
3+598	NBL	1		2				
	SBL		2		2	3	3	1
3+798	NBL	1		2				
	SBL		2		2	3	3	1
5+998	NBL	1		2				
	SBL		2		2	3	3	1

4.1.1.1 Pre-Trial Road 103 DCP Measurements

Descriptive statistics of Test Road 103 pre-trial DCP measurements have been previously noted and are summarized by lane and road segment in Table B-3 in Appendix B. The average DCP profiles are shown in Figures 4-1 and 4-2. Average north and southbound lane pre-trial profiles are in close agreement. As noted in Section 3.3.1, there is no significant statistical difference in mean DCP measurements between the test lanes of Test Road 103 at the 95% confidence level.

Average mm/blow values for the 4.8 km test road segment, increase from 6 at 25 mm to 22 at approximately 200 mm and at greater depths average 25 mm/blow.

For the 1.6 km segment south of Road 105, average mm/blow values within the upper 200 mm are similar in magnitude to those of the test road. At greater depths, the increase in mm/blow values is more pronounced than those of the test road, with values in the 30 to 40 mm/blow range at depths exceeding 600 mm.

4.1.1.2 Post-Trial Road 103 DCP Measurements

Average, standard deviation and coefficient of variation values of post-trial measurements are summarized in Table B-6 in Appendix B. Average profiles by road segment are shown in Figures 4-3 and 4-4.

Comparative analyses carried out on test road segment data indicated that, with the exception of the 25 mm measurements, the data does not provide sufficient evidence at the 95% level of significance to conclude that post-trial mean DCP values by lane are different.

At the time of terminating the trial, the southbound lane carrying the low tire pressures had been subjected to approximately 3.6 times the number of cumulative truck passes experienced by the high tire pressure northbound lane.

The crew performing the DCP testing used a subjective rating of road condition at each test location. The ratings were based on rut depth observations with minimal rutting described as "no failure", rut depths less than 50 mm as "start of failure" and depths larger than 50 mm as "failed". The ratings of August 2,2000 described 15 of the 25 northbound lane test sites, and 17 of the 25 southbound lane DCP locations as "failed" and two as receiving maintenance prior to terminating the trial.

4.1.1.3 Pre/Post-Trial DCP Comparisons-Road 103

Average pre and post-trial DCP profiles for the north and southbound lanes of the test road are shown in Figures 4-5 and 4-6, respectively. Analyses carried out on data populations indicated, with the exceptions of southbound lane DCP values to a depth of 75 mm, the data do not provide sufficient evidence, at 95% confidence level, to conclude that mean post-trial DCP values are different than pre-trial values. Comparative analyses of pre and post-trial DCP measurements on the 1.6 km segment of Test Road 103, south of Test Road 105, which was not subjected to the test traffic, yielded the same result.

4.1.1.4 During Trial Road 103 DCP Measurements

Using DCP profiles from tests carried out at stations and dates presented in Table 4-1, analyses were carried out to detect possible trends in the measurements with time; time being a surrogate for traffic. Analyses for a given station and lane involved comparing mm/blow values at depth increments of 25 mm with time of test. The variability in the measurements masked any potential mm/blow - time (traffic) trends.

The variability in measurements is reflected in the site-specific profiles shown in Figures C-1 through C-10 in Appendix C. In these figures, profiles representing days in which more than one test was conducted are average profiles. Reducing measurement variability, the average profiles were determined by aggregating test data for a given day into one population and applying a moving average to both mm/blow and depth readings. For completeness, profiles measured prior to and following the trials (July 12 and August 2) are included in the figures.

DCP tests at Stations 3+501 and 4+824 on July 31 and August 3 were used to obtain a measure of mm/blow variability. The tests included inner and outer wheelpath measurements in both lanes at each of the two stations. There was no haul on the northbound (high tire pressure) lane over the three days. The southbound lane was subjected to the last 146 passes of the nine-axle B trains at low tire pressure on August 1; after which haul operations were terminated.

Differences between July 31 and August 3 mm/blow values at equal depths were determined for each of the eight DCP locations. (The differences were found to be depth independent). By lane distributions of the differences are shown in Figures 4-7 and 4-8.

Subjected to no haul during the three days, August 3rd mm/blow values for the four northbound lane DCP sites were within ±5 mm/blow of July 31 values approximately 66% of the time and within ±10mm/blow approximately 95% the time. The corresponding standard deviation and two standard deviation for the mm/blow variations exhibited by the trafficked southbound lane DCP locations were 3 and 6, respectively. Thus any variation in DCP values of ±6 mm/blow could be caused by natural variations in the soil not necessarily by traffic damage. Most of the variability noted in the pre/post-evaluation presented in Figures 4-5 and 4-6 fall within the expected variability range.

4.1.2 Road 202 DCP Measurements

Pre-trial DCP tests on Road 202 were carried out July 11 and 12, 2000. Testing commenced 1.6 kms south of Junction 206. All tests were conducted at a 1.1 m lane centreline offset (in the outer wheelpaths) and at a 200 m spacing.

Post-trial DCP tests were conducted August 1 and 2, 2000 in the outer wheelpaths. The spacing between tests in the 1.6 kms south of Road 206 was increased from the pre-trial 200 m to 400 m.

During-trial test stations, dates and the number of tests at each station on a given day are summarized in Table 4-2. The during-trial tests were conducted in the outer wheelpaths.

Table 4-2 During-Trial DCP Tests

Station	Lane	26-Jul	27-Jul	28-Jul	29-Jul	30-Jul
2+797	NBL		1	2	2	2
	SBL		1	2	2	3
3+998	NBL	1				
	SBL	1				
4+977	NBL	1	1	2	2	2
	SBL	1	1	2	2	3
5+198	NBL	1				
	SBL	1				
5+398	NBL	1				
	SBL	1				
6+197	NBL	1	1	2	2	2
	SBL	1	2	1	2	3

4.1.2.1 Pre-Trial Road 202 DCP Measurements

Descriptive statistics of Road 202 pre-trial DCP measurements are summarized by lane and road segment in Table B-4 of Appendix B. Average profiles for the initial 1.6 kms and the test segment of the roadway are shown in Figures 4-9 and 4-10, respectively.

The northbound lane of the 1.6 kms to the south of the test road exhibited pre-trial mm/blow values significantly larger in magnitude than those of the southbound lane and those of the test road.

As noted in Section 3.2.2, comparative analyses of the test road north and southbound data indicated that, with the exception of mm/blow values at depths in 25 to 75 mm range, the pre-trial mean profiles for the two lanes are not statistically differently at the 95 percent confidence level.

4.1.2.2 Post-Trial Road 202 DCP Measurements

Post-trial DCP measurements are summarized by lane and road segment in Table B-7 of Appendix B. Average profiles for the initial 1.6 kms and the test segment of the roadway are shown in Figures 4-11 and 4-12. The DCP data worksheets identified eight of the 32 DCP stations in the northbound lane and two of the 32 DCP stations in the southbound lane that were repaired during the trial. The data summary and profiles exclude post-repair measurements.

Average north and southbound lane post-trial profiles for the test road segment are in close agreement. From the DCP files, with the exception of three DCP stations, the post-trial condition of all stations was described as one of "failure"; having rut depths greater than 50 mm.

4.1.2.3 Pre/Post Trial Profile Comparisons

Comparisons between pre-and post-trial profiles were carried out for various sites. Examples of these comparisons are shown in Figures C-1 through C-18 in Appendix C. For the majority of sites, post-trial DCP values tend to be either similar or larger in magnitude than pre-trial values. However, depths at which differences in DCP values occur and the magnitude of the differences are highly site dependent.

Excluding stations repaired from both the pre-and post-trial data populations, average pre-and post profiles by lane are presented in Figures 4-13 and 4-14. Analyses of the populations indicated that differences in pre and post-trial average profiles for the northbound (high tire pressure) lane are not significant at 95 percent confidence. Pre and post-trial southbound (low tire pressure) lane mean values are significantly different at 95 percent confidence at depths of 25 to 75mm but do not exhibit significant difference at lower depths.

4.1.2.4 During-Trial Road 202 DCP Measurements

During-trial DCP measurements at the six stations presented in Table 4-2 and Figures C-19 to C-30 in Appendix C. The figures include pre and post-trial profiles for each site. Prior to developing the plots, DCP measurements for a given day and site were examined and in cases where repeat tests on a given day yielded similar measurements the profiles were averaged. A bracketed number following the test date identifies average profiles in the legends of the figures. The number refers to the number of individual profiles comprising the average. Attempting to better identify individual data populations, many of the plots are in a scatter rather than line format. Comments, including the subjective condition rating, based on the previously mentioned rut depth criteria, assigned to the station at the time of testing and brief comparisons of the profiles, accompany the plots.

4.2 Walpole Test Site DCP Measurements

The Walpole trial was a demonstration project with DCP tests conducted prior to and following the trial.

Pre-trial measurements were:

- on Grid 601 from 11.2 kms south of the Highway 48 to Highway 48 and
- within the 6.4 kms of Highway 48 forming the northern segments of the two truck loops.

Post-trial measurements were:

- on the 4.8 kms of the north-south Main Farm Access Road forming the east segment of the reduced tire pressure loop,
- on the 4.8 kms of the north-south Grid Road comprising the west segment of the normal tire pressure loop and
- on the east-west 6.4 kms of the Grid and Farm Access road forming the southern segment of each loop.

The DCP tests were carried out at 500 m spacing alternating between lanes and to a depth of 1 metre. Results of DCP tests conducted on Grid 601 are shown in this report.

4.2.1 Pre-Trial DCP Measurements – Grid 601

Descriptive statistics of Grid 601 pre-trial DCP measurements are summarized by lane and road segment in Table B-7 in Appendix B. Average profiles are shown in Figures 4-15 and 4-16. The average north and southbound lane pre-trial profiles are in close agreement. Comparative analyses carried out on the data indicated that, with the exception of DCP measurements at 500 mm, there is no significance difference (95% confidence) between mean south and northbound lane DCP values. Differences between DCP measurements at the 500 mm depth are not significant at a 90 percent confidence level.

Average mm/blow values increase from approximately 6 mm/blow at 25 mm to 20 mm/blow at 300 mm and are generally in the 10 to 20 mm/blow range at greater depths.

4.3 Pre-Trial Walpole/Dafoe DCP Comparisons

The average pre-trial DCP profile for the trafficked 5 kms of Grid 601 Road at Walpole in 1999 (N=9) and the average pre-trial profile of the trafficked 4.8 kms of Road 103 at Big Quill in 2000 (N=50) are shown in Figure 4-17.

The average Big Quill DCP measurements are larger in magnitude than those of Walpole. From analysis carried out on the data populations, with the exception of 25, 50 and 300 mm depths, the data provide sufficient evidence to indicate that the pre-trial DCP values differ for the Big Quill and Walpole test roads.

4.4 Benkelman Beam Tests - Big Quill Test Site

Benkelman Beam tests were carried out on the two test roads, Roads 103 and 202. The tests were conducted prior to and during the trials on each of the roadways.

The following summarizes the Benkelman Beam measurements and presents results of comparative, by lane, analyses of the measurements.

The summaries for Roads 103 and 202 contain average and standard deviation values for the deflections in each lane. The average and standard deviation values were calculated for different periods of testing prior to and during the trial. The following sections present the data separated for the 1.6 km south of the actual trial road, for the gravel portion of the test road, and for the TMS portion of the test road. The TMS portion is considered to be both the seal coat and cold mix sections.

4.4.1 Road 103 Benkelman Beam Measurements

Benkelman Beam tests on Road 103 were conducted prior to and at regular locations during the trials. The deflections were generally obtained at regular locations.

Commencing 1.6 km south of the test road segment (1.6 km south of the junction of Road 103 and Road 105), pre-trial Benkelman Beam tests were carried out on July 11, 2000. Tests were in both lanes at 400 m intervals.

During the trial, Benkelman Beam tests were carried out in the northbound (high tire pressure) lane on July 24 (initial data - cold mix section), July 25 (initial data - 0.4 km intervals), July 26 and July 28 (2), 2000 (numbers in brackets refer to the number of complete Benkelman Beam tests that were conducted on that day). The tests were carried out at 400 m intervals with additional testing at 100 m intervals in the thin membrane surface section (Station 2+900 to Station 4+000). The trucks used in this lane were 9 axle B-trains with high tire pressure.

In the southbound (low tire pressure) lane, Benkelman Beam readings were obtained on July 24 (initial data - cold mix section), July 25 (initial data - 0.4 km intervals), July 27 (2), July 29 (2), July 30 (3), July 31 (3), 2000 and August 1 (2), 2000 (numbers in brackets refer to the number of complete Benkelman Beam tests that were conducted on that day). As with the northbound lane, the tests were at 400 m intervals with additional testing at 100 m intervals in the thin membrane surface section.

4.4.1.1 Northbound (High Tire Pressure) Lane

The pre- and during-trial test stations and deflections at 400 m intervals are shown in Table 4-3. There is no consistent trend of increasing deflections throughout the course of the trial. Table 4-4 provides the test stations and deflections for the thin membrane surface section.

Figures 4-18 and 4-19 depict the average daily deflections and a comparison of pre-trial and end of trial deflections, respectively. As Figure 4-18 shows, the largest average deflections were noted in the TMS. Figure 4-19 reflects the difference in roadway deflection from pre-trial to end of trial. The increases in deflections over the trial period for km 0.0 to km 1.6 are relatively insignificant. The deflection on the gravel section from km 1.6 to km 2.9 show some increase. However, deflections on the TMS and north gravel section increased significantly.

4.4.1.2 Southbound (Low Tire Pressure) Lane

The pre- and during-trial stations and deflections at 400 m intervals are shown on Table 4-5. As with the northbound lane, there is no consistent trend of increasing deflections throughout the course of the trial. Table 4-6 provides the stations and deflections for the thin membrane surface section. As with the northbound lane, there does not appear to be a consistent trend of increasing deflections over the trial period.

Table 4-3
Northbound Lane, Road 103 @ 0.4 km INTERVALS (Gravel)

July 25 Data (initial)			July 26 Data			July 28 AM Data			July 28 PM Data	
Station	Deflection		Station	Deflection		Station	Deflection		Station	Deflection
km	mm		km	mm		km	mm		km	mm
0.000	nr		0.000	1.6		0.000	2.84		0.000	3.12
0.400	2.52		0.400	2.6		0.400	1.96		0.400	3.46
0.800	2.16		0.800	2.36		0.800	3.6		0.800	3.36
1.200	1.24		1.200	2.12		1.200	2.52		1.200	2.66
1.600	1.56		1.600	1.8		1.600	3.84		1.600	3.74
2.000	1.88		2.000	4.08		2.000	4.3		2.000	4.56
2.400	2.16		2.400	4.44		2.400	4.6		2.400	4.66
2.800	1.36		2.800	2.96		2.800	3.48		2.800	3.44
4.400	2.52		4.400	3.76		4.400	5.2		4.400	6.98
4.800	1.36		4.800	7.72		4.800	6.1		4.800	6.62
5.200	1.52		5.200	2.6		5.200	1.76		5.200	2.26
5.600	1.48		5.600	3.6		5.600	4.44		5.600	3.86
6.000	1.76		6.000	6.36		6.000	6.4		6.000	8.64
6.400	2		6.400	7.56		6.400	8.2		6.400	7.16
AVERAGE:	1.809230769		AVERAGE:	3.83		AVERAGE:	4.23		AVERAGE:	4.61
STD. DEV.:	0.44		STD. DEV.:	2.04		STD. DEV.:	1.80		STD. DEV.:	1.95
COEFFICIENT OF VARIATION (%):	24.10		COEFFICIENT OF VARIATION (%):	53.22		COEFFICIENT OF VARIATION (%):	42.64		COEFFICIENT OF VARIATION (%):	42.35

Table 4-4
Northbound Lane, Road 103, TMS Section

	July 24/00 1200 Data		July 26/00 0745 Data		July 28/00 1130 Data		July 28/00 1930 Data	
	Station	Deflection	Station	Deflection	Station	Deflection	Station	Deflection
	km	mm	km	mm	km	mm	km	mm
SAND SEAL	2.900	1.68	2.900	2.88	2.900	3.48	2.900	2.96
	3.000	2.32	3.000	3.00	3.000	3.60	3.000	3.44
	3.100	1.56	3.100	3.20	3.100	3.60	3.100	3.96
	3.200	1.96	3.200	5.24	3.200	2.72	3.200	4.20
COLD MIX	3.300	2.28	3.300	3.88	3.300	3.52	3.300	4.70
	3.400	2.56	3.400	3.28	3.400	6.98	3.400	7.60
	3.500	2.88	3.500	3.60	3.500	3.76	3.500	4.58
	3.600	3.56	3.600	4.16	3.600	3.36	3.600	2.96
	3.700	3.04	3.700	5.42	3.700	4.06	3.700	6.98
SAND SEAL	3.800	2.30	3.800	3.12	3.800	2.60	3.800	6.80
	3.900	1.96	3.900	3.24	3.900	3.00	3.900	3.70
	4.000	2.00	4.000	2.40	4.000	4.96	4.000	2.56
	AVERAGE:	2.34	AVERAGE:	3.62	AVERAGE:	3.80	AVERAGE:	4.54
	STD. DEV.:	0.59	STD. DEV.:	0.92	STD. DEV.:	1.18	STD. DEV.:	1.70
	COEFFICIENT OF VARIATION (%):	25.01	COEFFICIENT OF VARIATION (%):	25.45	COEFFICIENT OF VARIATION (%):	30.94	COEFFICIENT OF VARIATION (%):	37.44

Table 4-5
Southbound Lane, Road 103 @ 0.4 km INTERVALS (Gravel)

July 25 (Initial) Data			July 27 AM Data			July 27 PM Data			July 29 AM Data		
Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection
(km)	(mm)	(mm)	(km)	(mm)	(mm)	(km)	(mm)	(mm)	(km)	(mm)	(mm)
0.000	nr	N/A	0.000	92	1.84	0.000	133	2.66	0.000	104	2.08
0.400	74	1.48	0.400	202	4.04	0.400	221	4.42	0.400	210	4.20
0.800	68	1.36	0.800	124	2.48	0.800	154	3.08	0.800	106	2.12
1.200	66	1.32	1.200	86	1.72	1.200	92	1.84	1.200	77	1.54
1.600	150	3.00	1.600	238	4.76	1.600	252	5.04	1.600	254	5.08
2.000	108	2.16	2.000	230	4.60	2.000	250	5.00	2.000	242	4.84
2.400	186	3.72	2.400	185	3.70	2.400	191	3.82	2.400	240	4.80
2.800	66	1.32	2.800	122	2.44	2.800	112	2.24	2.800	128	2.56
4.400	74	1.48	4.400	104	2.08	4.400	92	1.84	4.400	118	2.36
4.800	72	1.44	4.800	182	3.64	4.800	113	2.26	4.800	155	3.10
5.200	74	1.48	5.200	98	1.96	5.200	104	2.08	5.200	115	2.30
5.600	90	1.80	5.600	166	3.32	5.600	116	2.32	5.600	154	3.08
6.000	70	1.40	6.000	114	2.28	6.000	100	2.00	6.000	115	2.30
6.400	56	1.12	6.400	172	3.44	6.400	195	3.90	6.400	130	2.60
AVERAGE:	88.77	1.78	AVERAGE:	151.07	3.02	AVERAGE:	151.79	3.04	AVERAGE:	153.43	3.07
STD. DEV.:	38.08	0.76	STD. DEV.:	51.78	1.04	STD. DEV.:	58.65	1.17	STD. DEV.:	58.57	1.17
COEFFICIENT OF VARIATION (%)	42.90	42.90	COEFFICIENT OF VARIATION (%)	34.28	34.28	COEFFICIENT OF VARIATION (%)	38.64	38.64	COEFFICIENT OF VARIATION (%)	38.17	38.17

July 29 PM Data			July 30 AM Data			July 30 PM (2:45) Data			July 30 PM (6:15) Data		
Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection
(km)	(mm)	(mm)	(km)	(mm)	(mm)	(km)	(mm)	(mm)	(km)	(mm)	(mm)
0.000	nr	N/A	0.000	nr	N/A	0.000	nr	N/A	0.000	108	2.16
0.400	nr	N/A	0.400	nr	N/A	0.400	nr	N/A	0.400	126	2.52
0.800	nr	N/A	0.800	nr	N/A	0.800	nr	N/A	0.800	103	2.06
1.200	nr	N/A	1.200	nr	N/A	1.200	nr	N/A	1.200	82	1.64
1.600	nr	N/A	1.600	nr	N/A	1.600	nr	N/A	1.600	154	3.08
2.000	278	5.56	2.000	206	4.12	2.000	234	4.68	2.000	255	5.10
2.400	268	5.36	2.400	180	3.60	2.400	224	4.48	2.400	250	5.00
2.800	134	2.68	2.800	118	2.36	2.800	110	2.20	2.800	45	0.90
4.400	114	2.28	4.400	97	1.94	4.400	104	2.08	4.400	112	2.24
4.800	185	3.70	4.800	153	3.06	4.800	305	6.10	4.800	230	4.60
5.200	98	1.96	5.200	82	1.64	5.200	74	1.48	5.200	78	1.56
5.600	150	3.00	5.600	152	3.04	5.600	154	3.08	5.600	140	2.80
6.000	132	2.64	6.000	130	2.60	6.000	110	2.20	6.000	95	1.90
6.400	228	4.56	6.400	174	3.48	6.400	210	4.20	6.400	230	4.60
AVERAGE:	176.33	3.53	AVERAGE:	143.56	2.87	AVERAGE:	169.44	3.39	AVERAGE:	143.43	2.87
STD. DEV.:	67.04	1.34	STD. DEV.:	40.48	0.81	STD. DEV.:	77.35	1.55	STD. DEV.:	69.72	1.39
COEFFICIENT OF VARIATION (%)	38.02	38.02	COEFFICIENT OF VARIATION (%)	28.20	28.20	COEFFICIENT OF VARIATION (%)	45.65	45.65	COEFFICIENT OF VARIATION (%)	48.61	48.61

Table 4-5 (cont.,)
Southbound Lane, Road 103 @ 0.5 km INTERVALS (Gravel)

July 31 AM (10:00) Data			July 31 PM (12:30) Data			July 31 PM (4:40) Data			August 1 AM (10:45) Data		
Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection
(km)	(mm)	(mm)	(km)	(mm)	(mm)	(km)	(mm)	(mm)	(km)	(mm)	(mm)
0.000	nr	N/A	0.000	nr	N/A	0.000	nr	N/A	0.000	nr	N/A
0.400	nr	N/A	0.400	nr	N/A	0.400	nr	N/A	0.400	nr	N/A
0.800	nr	N/A	0.800	nr	N/A	0.800	nr	N/A	0.800	nr	N/A
1.200	nr	N/A	1.200	nr	N/A	1.200	nr	N/A	1.200	nr	N/A
1.600	nr	N/A	1.600	nr	N/A	1.600	nr	N/A	1.600	nr	N/A
2.000	282	5.64	2.000	310	6.20	2.000	282	5.64	2.000	262	5.24
2.400	228	4.56	2.400	242	4.84	2.400	190	3.80	2.400	218	4.36
2.800	100	2.00	2.800	89	1.78	2.800	104	2.08	2.800	112	2.24
4.400	92	1.84	4.400	90	1.80	4.400	129	2.58	4.400	100	2.00
4.800	610	12.20	4.800	380	7.60	4.800	460	9.20	4.800	320	6.40
5.200	90	1.80	5.200	95	1.90	5.200	110	2.20	5.200	88	1.76
5.600	100	2.00	5.600	128	2.56	5.600	192	3.84	5.600	138	2.76
6.000	98	1.96	6.000	104	2.08	6.000	130	2.60	6.000	100	2.00
6.400	218	4.36	6.400	270	5.40	6.400	250	5.00	6.400	203	4.06
AVERAGE:	202.00	4.04	AVERAGE:	189.78	3.80	AVERAGE:	205.22	4.10	AVERAGE:	171.22	3.42
STD. DEV.:	169.58	3.39	STD. DEV.:	111.84	2.24	STD. DEV.:	114.02	2.28	STD. DEV.:	83.11	1.66
COEFFICIENT OF VARIATION (%)	83.95	83.95	COEFFICIENT OF VARIATION (%)	58.93	58.93	COEFFICIENT OF VARIATION (%)	55.56	55.56	COEFFICIENT OF VARIATION (%)	48.54	48.54

August 1 PM (3:45) Data		
Station	Beam Rdg.	Deflection
(km)	(mm)	(mm)
0.000	nr	N/A
0.400	nr	N/A
0.800	nr	N/A
1.200	nr	N/A
1.600	nr	N/A
2.000	242	4.84
2.400	230	4.60
2.800	102	2.04
4.400	95	1.90
4.800	325	6.50
5.200	92	1.84
5.600	132	2.64
6.000	92	1.84
6.400	220	4.40
AVERAGE:	170.00	3.40
STD. DEV.:	86.00	1.72
COEFFICIENT OF VARIATION (%)	50.59	50.59

Table 4-6
Southbound Lane, Road 103, TMS Section

	July 24/00 (Initial) Data			July 27/00 AM Data			July 27/00 PM Data			July 29/00 AM Data		
	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection
	km	mm	mm	km	mm	mm	km	mm	mm	km	mm	mm
SAND SEAL	2.900	140	2.80	2+900	269	5.38	2+900	178	3.56	2+900	164	3.28
	3.000	94	1.88	3+000	181	3.62	3+000	224	4.48	3+000	253	5.06
	3.100	172	3.44	3+100	224	4.48	3+100	195	3.90	3+100	386	7.72
	3.200	158	3.16	3+200	383	7.66	3+200	310	6.20	3+200	300	6.00
COLD MIX	3.300	144	2.88	3+300	262	5.24	3+300	287	5.74	3+300	174	3.48
	3.400	120	2.40	3+400	226	4.52	3+400	215	4.30	3+400	216	4.32
	3.500	142	2.84	3+500	244	4.88	3+500	200	4.00	3+500	214	4.28
	3.600	278	5.56	3+600	326	6.52	3+600	188	3.76	3+600	332	6.64
	3.700	264	5.28	3+700	352	7.04	3+700	298	5.96	3+700	180	3.60
SAND SEAL	3.800	154	3.08	3+800	206	4.12	3+800	237	4.74	3+800	290	5.80
	3.900	168	3.36	3+900	189	3.78	3+900	268	5.36	3+900	240	4.80
	4.000	112	2.24	4+000	174	3.48	4+000	150	3.00	4+000	310	6.20
	AVERAGE:	162.17	3.24	AVERAGE:	253.00	5.06	AVERAGE:	229.17	4.58	AVERAGE:	254.92	5.10
	STD. DEV.:	55.74	1.11	STD. DEV.:	68.59	1.37	STD. DEV.:	51.36	1.03	STD. DEV.:	69.59	1.39
	COEFFICIENT OF VARIATION (%)	34.37	34.37	COEFFICIENT OF VARIATION (%)	27.11	27.11	COEFFICIENT OF VARIATION (%)	22.41	22.41	COEFFICIENT OF VARIATION (%)	27.30	27.30

	July 29/00 PM Data			July 30/00 AM Data			July 30/00 2:45 PM Data			July 30/00 6:15 PM Data		
	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection
	km	mm	mm	km	mm	mm	km	mm	mm	km	mm	mm
SAND SEAL	2+900	152	3.04	2+900	208	4.16	2+900	137	2.74	2+900	148	2.96
	3+000	130	2.60	3+000	174	3.48	3+000	200	4.00	3+000	125	2.50
	3+100	208	4.16	3+100	338	6.76	3+100	300	6.00	3+100	240	4.80
	3+200	230	4.60	3+200	232	4.64	3+200	362	7.24	3+200	203	4.06
COLD MIX	3+300	230	4.60	3+300	226	4.52	3+300	214	4.28	3+300	198	3.96
	3+400	270	5.40	3+400	172	3.44	3+400	206	4.12	3+400	178	3.56
	3+500	104	2.08	3+500	160	3.20	3+500	184	3.68	3+500	142	2.84
	3+600	214	4.28	3+600	137	2.74	3+600	220	4.40	3+600	155	3.10
	3+700	252	5.04	3+700	132	2.64	3+700	284	5.68	3+700	102	2.04
SAND SEAL	3+800	160	3.20	3+800	157	3.14	3+800	208	4.16	3+800	280	5.60
	3+900	203	4.06	3+900	96	1.92	3+900	236	4.72	3+900	252	5.04
	4+000	197	3.94	4+000	138	2.76	4+000	200	4.00	4+000	270	5.40
	AVERAGE:	195.83	3.92	AVERAGE:	180.83	3.62	AVERAGE:	229.25	4.59	AVERAGE:	191.08	3.82
	STD. DEV.:	49.99	1.00	STD. DEV.:	63.65	1.27	STD. DEV.:	59.73	1.19	STD. DEV.:	59.14	1.18
	COEFFICIENT OF VARIATION (%)	25.53	25.53	COEFFICIENT OF VARIATION (%)	35.20	35.20	COEFFICIENT OF VARIATION (%)	26.06	26.06	COEFFICIENT OF VARIATION (%)	30.95	30.95

Table 4-6 (cont.,)
Southbound Lane, Road 103, TMS Section

	July 31/00 10:00 AM Data			July 31/00 12:30 PM Data			July 31/00 4:40 PM Data			August 1/00 10:45 AM Data		
	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection	Station	Beam Rdg.	Deflection
	km	mm	mm	km	mm	mm	km	mm	mm	km	mm	mm
SAND SEAL	2+900	182	3.64	2+900	162	3.24	2+900	130	2.60	2+900	152	3.04
	3+000	197	3.94	3+000	180	3.60	3+000	132	2.64	3+000	220	4.40
	3+100	374	7.48	3+100	344	6.88	3+100	320	6.40	3+100	274	5.48
	3+200	292	5.84	3+200	342	6.84	3+200	274	5.48	3+200	218	4.36
COLD MIX	3+300	242	4.84	3+300	210	4.20	3+300	248	4.96	3+300	226	4.52
	3+400	264	5.28	3+400	242	4.84	3+400	248	4.96	3+400	195	3.90
	3+500	208	4.16	3+500	200	4.00	3+500	228	4.56	3+500	190	3.80
	3+600	256	5.12	3+600	220	4.40	3+600	330	6.60	3+600	284	5.68
	3+700	290	5.80	3+700	314	6.28	3+700	304	6.08	3+700	214	4.28
SAND SEAL	3+800	210	4.20	3+800	262	5.24	3+800	292	5.84	3+800	214	4.28
	3+900	260	5.20	3+900	420	8.40	3+900	268	5.36	3+900	240	4.80
	4+000	288	5.76	4+000	250	5.00	4+000	190	3.80	4+000	270	5.40
	AVERAGE:	255.25	5.11	AVERAGE:	262.17	5.24	AVERAGE:	247.00	4.94	AVERAGE:	224.75	4.50
	STD. DEV.:	53.13	1.06	STD. DEV.:	77.68	1.55	STD. DEV.:	66.87	1.34	STD. DEV.:	38.02	0.76
	COEFFICIENT OF VARIATION (%)	20.81	20.81	COEFFICIENT OF VARIATION (%)	29.63	29.63	COEFFICIENT OF VARIATION (%)	27.07	27.07	COEFFICIENT OF VARIATION (%)	16.92	16.92

	August 1/00 3:45 PM Data		
	Station	Beam Rdg.	Deflection
	km	mm	mm
SAND SEAL	2+900	240	4.80
	3+000	207	4.14
	3+100	262	5.24
	3+200	164	3.28
COLD MIX	3+300	200	4.00
	3+400	120	2.40
	3+500	145	2.90
	3+600	192	3.84
	3+700	200	4.00
SAND SEAL	3+800	160	3.20
	3+900	165	3.30
	4+000	230	4.60
	AVERAGE:	190.42	3.81
	STD. DEV.:	41.45	0.83
	COEFFICIENT OF VARIATION (%)	21.77	21.77

Figures 4-20 and 4-21 depict the average daily deflections and a comparison of pre-trial and end of trial deflections, respectively. As Figure 4-20 shows, the greatest deflections were noted in the TMS portion of the road. Figure 4-21 reflects the difference in roadway deflection from pre-trial to end of trial. As for the northbound lane the no traffic section south of km 1.6 showed almost no change. However, the south gravel section and the TMS showed significant increase in deflection.

4.4.2 Road 202 Benkelman Beam Measurements

Benkelman Beam tests on Road 202 were also conducted prior to and at regular time intervals during the trial.

Commencing 1.6 km south of the test road segment (1.6 km south of the junction of Test Road 202 and Road 206), pre-trial Benkelman Beam tests were carried out on July 10, 2000. Tests were in both lanes at 400 m intervals.

During the trial, Benkelman Beam tests were carried out in the northbound (high tire pressure) lane on July 24 (initial data - all sections), July 26, July 27, July 28 (2), July 29 (2), and July 30 (2), 2000. As for Test Road 103, the numbers in brackets refer to the number of complete beam tests done on one day. The tests were carried out at 400 m intervals with additional testing at 100 m intervals in the TMS section (Station 4+900 to Station 5+700). The trucks used on the northbound lane were a mixed fleet of 8-axle B-trains and 6-axle trucks. High tire pressure was specified for this lane.

In the southbound (low tire pressure) lane, Benkelman Beam tests were carried out on July 24 (initial data - all sections), July 26, July 27, July 28 (2), July 29 (2), and July 30 (3), 2000. As with the northbound lane, the tests were at 400 m intervals with additional testing at 100 m intervals in the cold mix section. The trucks used in this lane were 9-axle B-trains with low tire pressures.

4.4.2.1 Northbound (High Tire Pressure) Lane

The pre- and during-trial stations and deflections at 400 m intervals are shown on Table 4-7. There is no consistent trend of increasing deflections throughout the course of the trial. Table 4-8 provides the stations and deflections for the TMS section. Benkelman Beam readings for Stations 4+900 to 5+700 were discontinued after July 29, 2000 because

the TMS section failed and was repaired. However, based on the available data, there is no consistent trend towards increasing deflections over the course of the trial.

Figures 4-22 and 4-23 depict the average daily deflections and a comparison of pre-trial, mid-trial and post-trial deflections, respectively. As Figure 4-22 shows, the greatest deflections were noted in the TMS portion of the road. Figure 4-23 reflects the difference in roadway deflection between pre-trial, mid-trial, and post-trial. The increases in deflections between start and end of the trial period appear relatively insignificant. As is shown in Figure 4-23, the deflections at mid-trial were generally greater than the post-trial deflections for the north portion of the lane (Station 4+800 northward). The difference in deflection in the south portion (Station 1+600 to 4+400) was generally <2 mm throughout the course of the trial.

4.4.2.2 Southbound (Low Tire Pressure) Lane

The pre- and during-trial stations and deflections at 400 m intervals are shown on Table 4-9. As with the northbound lane, there is no consistent trend of increasing deflections throughout the course of the trial. Table 4-10 provides the stations and deflections for the thin membrane surface section. Benkelman Beam readings for Stations 4+900 to 5+700 were discontinued after July 29 because the entire TMS section was repaired. However, based on the available data, there does not appear to be a consistent trend of increasing deflections over the trial period.

Figures 4-24 and 4-25 depict the average daily deflections and a comparison of pre-trial, mid-trial and post-trial deflections, respectively. As Figure 4-24 shows, the greatest deflections were generally noted in the thin membrane surfaced portion of the road. Figure 4-25 reflects the difference in roadway deflection between pre-trial, mid-trial, and post-trial. There are some increases in deflection ranging up to ~4.4 mm. However, as is shown on the figure the deflections at mid-trial are generally greater than at the end of trial.

Table 4-7
Northbound Lane, Road 202 @ 0.4 km INTERVALS (Gravel)

July 24 (Initial) Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	166	3.32
0.800	176	3.52
1.200	230	4.60
1.600	82	1.64
2.000	54	1.08
2.400	64	1.28
2.800	108	2.16
3.200	86	1.72
3.600	92	1.84
4.000	112	2.24
4.400	84	1.68
6.000	100	2.00
6.400	102	2.04
6.800	120	2.40
7.200	148	2.96
7.600	62	1.24
8.000	54	1.08
AVERAGE	108.24	2.16
STD. DEV.	47.83	0.96
COEFFICIENT OF VARIATION (%)	44.19	44.19

July 26 19:00 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	172	3.44
0.800	186	3.72
1.200	238	4.76
1.600	78	1.56
2.000	116	2.32
2.400	132	2.64
2.800	180	3.60
3.200	202	4.04
3.600	306	6.12
4.000	240	4.80
4.400	310	6.20
6.000	172	3.44
6.400	152	3.04
6.800	200	4.00
7.200	270	5.40
7.600	152	3.04
8.000	100	2.00
AVERAGE	188.59	3.77
STD. DEV.	67.27	1.35
COEFFICIENT OF VARIATION (%)	35.67	35.67

July 27 11:00 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	nr	n/a
0.800	nr	n/a
1.200	nr	n/a
1.600	nr	n/a
2.000	119	2.38
2.400	104	2.08
2.800	176	3.52
3.200	260	5.20
3.600	222	4.44
4.000	392	7.84
4.400	130	2.60
6.000	120	2.40
6.400	204	4.08
6.800	202	4.04
7.200	nr	n/a
7.600	138	2.76
8.000	82	1.64
AVERAGE	179.08	3.58
STD. DEV.	85.89	1.72
COEFFICIENT OF VARIATION (%)	47.96	47.96

July 28 11:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	nr	n/a
0.800	nr	n/a
1.200	nr	n/a
1.600	nr	n/a
2.000	128	2.56
2.400	112	2.24
2.800	232	4.64
3.200	224	4.48
3.600	300	6.00
4.000	nr	n/a
4.400	328	6.56
6.000	170	3.40
6.400	190	3.80
6.800	226	4.52
7.200	860	17.20
7.600	146	2.92
8.000	98	1.96
AVERAGE	251.17	5.02
STD. DEV.	204.52	4.09
COEFFICIENT OF VARIATION (%)	81.43	81.43

July 28 18:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	nr	n/a
0.800	nr	n/a
1.200	nr	n/a
1.600	nr	n/a
2.000	132	2.64
2.400	116	2.32
2.800	248	4.96
3.200	262	5.24
3.600	200	4.00
4.000	nr	n/a
4.400	252	5.04
6.000	274	5.48
6.400	372	7.44
6.800	302	6.04
7.200	408	8.16
7.600	140	2.80
8.000	116	2.32
AVERAGE	235.17	4.70
STD. DEV.	97.74	1.95
COEFFICIENT OF VARIATION (%)	41.56	41.56

July 29 10:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	nr	n/a
0.800	nr	n/a
1.200	nr	n/a
1.600	nr	n/a
2.000	132	2.64
2.400	168	3.36
2.800	238	4.76
3.200	276	5.52
3.600	202	4.04
4.000	nr	n/a
4.400	162	3.24
6.000	206	4.12
6.400	248	4.96
6.800	nr	n/a
7.200	nr	n/a
7.600	132	2.64
8.000	146	2.92
AVERAGE	191.00	3.82
STD. DEV.	50.97	1.02
COEFFICIENT OF VARIATION (%)	26.69	26.69

July 29 16:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	nr	n/a
0.800	nr	n/a
1.200	nr	n/a
1.600	nr	n/a
2.000	150	3.00
2.400	174	3.48
2.800	270	5.40
3.200	234	4.68
3.600	204	4.08
4.000	nr	n/a
4.400	148	2.96
6.000	166	3.32
6.400	226	4.52
6.800	nr	n/a
7.200	nr	n/a
7.600	104	2.08
8.000	146	2.92
AVERAGE	#REF!	#REF!
STD. DEV.	50.27	1.01
COEFFICIENT OF VARIATION (%)	#REF!	#REF!

July 30 09:00 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	n/a
0.400	164	3.28
0.800	156	3.12
1.200	122	2.44
1.600	84	1.68
2.000	122	2.44
2.400	204	4.08
2.800	232	4.64
3.200	234	4.68
3.600	254	5.08
4.000	nr	n/a
4.400	552	11.04
6.000	182	3.64
6.400	184	3.68
6.800	nr	n/a
7.200	nr	n/a
7.600	86	1.72
8.000	92	1.84
AVERAGE	190.57	3.81
STD. DEV.	118.28	2.37
COEFFICIENT OF VARIATION (%)	62.07	62.07

Table 4-7 (cont.,)
Northbound Lane, Road 202 @ 0.4 km INTERVALS (Gravel)

July 30 13:30 Data			
Station	Beam Rdg	Deflection	
km	mm	mm	
0	nr	n/a	
0.400	nr	n/a	
0.800	nr	n/a	
1.200	nr	n/a	
1.600	nr	n/a	
2.000	126	2.52	
2.400	202	4.04	
2.800	220	4.40	
3.200	284	5.68	
3.600	296	5.92	
4.000	nr	n/a	
4.400	286	5.72	
6.000	184	3.68	
6.400	nr	n/a	
6.800	182	3.64	
7.200	nr	n/a	
7.600	98	1.96	
8.000	106	2.12	
AVERAGE:	198.40	3.97	
STD. DEV.:	74.04	1.48	
COEFFICIENT OF VARIATION (%)	37.32	37.32	

Table 4-8
Northbound Lane, Road 202, TMS Section

	July 24 (Initial) Data				July 26 19:00 Data				July 27 11:00 Data				July 28 11:30 Data		
	Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection
	km	mm	mm		km	mm	mm		km	mm	mm		km	mm	mm
SAND SEAL	4.800	120	2.40		4.800	254	5.08		4.800	278	5.56		4.800	160	3.20
COLD MIX	4.900	120	2.40		4.900	282	5.64		4.900	222	4.44		4.900	220	4.40
	5.000	122	2.44		5.000	312	6.24		5.000	282	5.64		5.000	342	6.84
	5.100	112	2.24		5.100	218	4.36		5.100	134	2.68		5.100	224	4.48
	5.200	148	2.96		5.200	204	4.08		5.200	144	2.88		5.200	196	3.92
	5.300	148	2.96		5.300	264	5.28		5.300	176	3.52		5.300	310	6.20
	5.400	148	2.96		5.400	290	5.80		5.400	262	5.24		5.400	282	5.64
	5.500	194	3.88		5.500	198	3.96		5.500	146	2.92		5.500	158	3.16
	5.600	180	3.60		5.600	620	12.40		5.600	470	9.40		5.600	610	12.20
	5.700	128	2.56		5.700	152	3.04		5.700	260	5.20		5.700	170	3.40
	AVERAGE:	142.00	2.84		AVERAGE:	279.40	5.59		AVERAGE:	237.40	4.75		AVERAGE:	267.20	5.34
	STD. DEV.:	27.33	0.55		STD. DEV.:	129.26	2.59		STD. DEV.:	100.35	2.01		STD. DEV.:	136.29	2.73
	COEFFICIENT OF VARIATION (%)	19.24	19.24		COEFFICIENT OF VARIATION (%)	46.27	46.27		COEFFICIENT OF VARIATION (%)	42.27	42.27		COEFFICIENT OF VARIATION (%)	51.01	51.01

	July 28 18:30 Data				July 29 10:30 Data				July 29 16:30 Data				July 30 09:00 Data		
	Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection
	km	mm	mm		km	mm	mm		km	mm	mm		km	mm	mm
SAND SEAL	4.800	354	7.08		4.800	204	4.08		4.800	486	9.72		4.800	230	4.60
COLD MIX	4.900	220	4.40		4.900	502	10.04		4.900	450	9.00		4.900	nr	N/A
	5.000	354	7.08		5.000	296	5.92		5.000	262	5.24		5.000	nr	N/A
	5.100	210	4.20		5.100	nr	N/A		5.100	nr	N/A		5.100	nr	N/A
	5.200	320	6.40		5.200	nr	N/A		5.200	nr	N/A		5.200	nr	N/A
	5.300	318	6.36		5.300	nr	N/A		5.300	nr	N/A		5.300	nr	N/A
	5.400	284	5.68		5.400	nr	N/A		5.400	nr	N/A		5.400	nr	N/A
	5.500	156	3.12		5.500	nr	N/A		5.500	nr	N/A		5.500	nr	N/A
	5.600	578	11.56		5.600	nr	N/A		5.600	nr	N/A		5.600	nr	N/A
	5.700	204	4.08		5.700	204	4.08		5.700	192	3.84		5.700	nr	N/A
	AVERAGE:	299.80	6.00		AVERAGE:	301.50	6.03		AVERAGE:	347.50	6.95		AVERAGE:	N/A	N/A
	STD. DEV.:	119.51	2.39		STD. DEV.:	140.53	2.81		STD. DEV.:	142.80	2.86		STD. DEV.:	N/A	N/A
	COEFFICIENT OF VARIATION (%)	39.86	39.86		COEFFICIENT OF VARIATION (%)	46.61	46.61		COEFFICIENT OF VARIATION (%)	41.09	41.09		COEFFICIENT OF VARIATION (%)	N/A	N/A

Table 4-8 (cont.,)
Northbound Lane, Road 202, TMS Section

	July 30 13:30 Data			
	Station	Beam Rdg	Deflection	
	km	mm	mm	
SAND SEAL	4.800	226	4.52	
COLD MIX	4.900	nr	N/A	
	5.000	nr	N/A	
	5.100	nr	N/A	
	5.200	nr	N/A	
	5.300	nr	N/A	
	5.400	nr	N/A	
	5.500	nr	N/A	
	5.600	nr	N/A	
	5.700	nr	N/A	
	AVERAGE:	N/A	N/A	
	STD. DEV.:	N/A	N/A	
	COEFFICIENT OF VARIATION (%)	N/A	N/A	

Table 4-9
Southbound Lane, Road 202 @ 0.4 km INTERVALS (Gravel)

July 24 (Initial) Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	156	3.12
0.800	284	5.68
1.200	172	3.44
1.600	84	1.68
2.000	68	1.36
2.400	76	1.52
2.800	80	1.60
3.200	108	2.16
3.600	100	2.00
4.000	114	2.28
4.400	94	1.88
6.000	106	2.12
6.400	128	2.56
6.800	82	1.64
7.200	116	2.32
7.600	60	1.20
8.000	62	1.24
AVERAGE:	111.18	2.22
STD. DEV.:	54.23	1.08
COEFFICIENT OF VARIATION (%)	48.78	48.78

July 26 19:00 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	170	3.40
0.800	274	5.48
1.200	180	3.60
1.600	86	1.72
2.000	110	2.20
2.400	124	2.48
2.800	160	3.20
3.200	194	3.88
3.600	180	3.60
4.000	274	5.48
4.400	146	2.92
6.000	228	4.56
6.400	166	3.32
6.800	94	1.88
7.200	220	4.40
7.600	100	2.00
8.000	94	1.88
AVERAGE:	164.71	3.29
STD. DEV.:	60.06	1.20
COEFFICIENT OF VARIATION (%)	36.46	36.46

July 27 11:00 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	nr	N/A
0.800	nr	N/A
1.200	nr	N/A
1.600	nr	N/A
2.000	140	2.80
2.400	104	2.08
2.800	114	2.28
3.200	318	6.36
3.600	160	3.20
4.000	372	7.44
4.400	162	3.24
6.000	370	7.40
6.400	244	4.88
6.800	128	2.56
7.200	212	4.24
7.600	170	3.40
8.000	124	2.48
AVERAGE:	201.38	4.03
STD. DEV.:	95.56	1.91
COEFFICIENT OF VARIATION (%)	47.45	47.45

July 28 11:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	nr	N/A
0.800	nr	N/A
1.200	nr	N/A
1.600	nr	N/A
2.000	152	3.04
2.400	86	1.72
2.800	128	2.56
3.200	296	5.92
3.600	152	3.04
4.000	366	7.32
4.400	160	3.20
6.000	458	9.16
6.400	252	5.04
6.800	168	3.36
7.200	230	4.60
7.600	100	2.00
8.000	124	2.48
AVERAGE:	205.54	4.11
STD. DEV.:	110.95	2.22
COEFFICIENT OF VARIATION (%)	53.98	53.98

July 28 18:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	nr	N/A
0.800	nr	N/A
1.200	nr	N/A
1.600	nr	N/A
2.000	162	3.24
2.400	94	1.88
2.800	134	2.68
3.200	310	6.20
3.600	172	3.44
4.000	376	7.52
4.400	180	3.60
6.000	338	6.76
6.400	320	6.40
6.800	132	2.64
7.200	228	4.56
7.600	138	2.76
8.000	130	2.60
AVERAGE:	208.77	4.18
STD. DEV.:	94.82	1.90
COEFFICIENT OF VARIATION (%)	45.42	45.42

July 29 10:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	nr	N/A
0.800	nr	N/A
1.200	nr	N/A
1.600	nr	N/A
2.000	152	3.04
2.400	160	3.20
2.800	132	2.64
3.200	296	5.92
3.600	150	3.00
4.000	222	4.44
4.400	133	2.66
6.000	340	6.80
6.400	228	4.56
6.800	110	2.20
7.200	192	3.84
7.600	124	2.48
8.000	140	2.80
AVERAGE:	183.00	3.66
STD. DEV.:	70.35	1.41
COEFFICIENT OF VARIATION (%)	38.44	38.44

July 29 16:30 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	nr	N/A
0.800	nr	N/A
1.200	nr	N/A
1.600	nr	N/A
2.000	174	3.48
2.400	158	3.16
2.800	112	2.24
3.200	290	5.80
3.600	162	3.24
4.000	304	6.08
4.400	228	4.56
6.000	316	6.32
6.400	186	3.72
6.800	112	2.24
7.200	240	4.80
7.600	116	2.32
8.000	138	2.76
AVERAGE:	195.08	3.90
STD. DEV.:	73.55	1.47
COEFFICIENT OF VARIATION (%)	37.70	37.70

July 30 09:00 Data		
Station	Beam Rdg	Deflection
km	mm	mm
0	nr	N/A
0.400	160	3.20
0.800	118	2.36
1.200	120	2.40
1.600	82	1.64
2.000	134	2.68
2.400	126	2.52
2.800	132	2.64
3.200	370	7.40
3.600	194	3.88
4.000	282	5.64
4.400	144	2.88
6.000	354	7.08
6.400	246	4.92
6.800	114	2.28
7.200	246	4.92
7.600	122	2.44
8.000	140	2.80
AVERAGE:	181.41	3.63
STD. DEV.:	86.98	1.74
COEFFICIENT OF VARIATION (%)	47.95	47.95

Table 4-9 (cont.,)
Southbound Lane, Road 202 @ 0.4 km INTERVALS (Gravel)

July 30 13:30 Data				July 30 17:30 Data		
Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection
km	mm	mm		km	mm	mm
0	nr	N/A		0	nr	N/A
0.400	nr	N/A		0.400	nr	N/A
0.800	nr	N/A		0.800	nr	N/A
1.200	nr	N/A		1.200	nr	N/A
1.600	nr	N/A		1.600	nr	N/A
2.000	134	2.68		2.000	136	2.72
2.400	114	2.28		2.400	120	2.40
2.800	134	2.68		2.800	124	2.48
3.200	346	6.92		3.200	278	5.56
3.600	198	3.96		3.600	198	3.96
4.000	238	4.76		4.000	404	8.08
4.400	150	3.00		4.400	142	2.84
6.000	374	7.48		6.000	298	5.96
6.400	182	3.64		6.400	178	3.56
6.800	124	2.48		6.800	120	2.40
7.200	252	5.04		7.200	112	2.24
7.600	146	2.92		7.600	120	2.40
8.000	120	2.40		8.000	128	2.56
AVERAGE:	193.23	3.86		AVERAGE:	181.38	3.63
STD. DEV.:	86.20	1.72		STD. DEV.:	90.67	1.81
COEFFICIENT OF VARIATION (%)	44.61	44.61		COEFFICIENT OF VARIATION (%)	49.99	49.99

Table 4-10
Southbound Lane, Road 202, TMS Section

	July 24 (Initial) Data			July 26 19:00 Data			July 27 11:00 Data			July 28 11:30 Data		
	Station	Beam Rdg	Deflection	Station	Beam Rdg	Deflection	Station	Beam Rdg	Deflection	Station	Beam Rdg	Deflection
	km	mm	mm	km	mm	mm	km	mm	mm	km	mm	mm
SAND SEAL	4.800	124	2.48	4.800	158	3.16	4.800	118	2.36	4.800	102	2.04
COLD MIX	4.900	104	2.08	4.900	314	6.28	4.900	240	4.80	4.900	252	5.04
	5.000	98	1.96	5.000	146	2.92	5.000	142	2.84	5.000	150	3.00
	5.100	120	2.40	5.100	220	4.40	5.100	218	4.36	5.100	170	3.40
	5.200	216	4.32	5.200	338	6.76	5.200	108	2.16	5.200	390	7.80
	5.300	188	3.76	5.300	324	6.48	5.300	292	5.84	5.300	462	9.24
	5.400	270	5.40	5.400	362	7.24	5.400	248	4.96	5.400	300	6.00
	5.500	196	3.92	5.500	272	5.44	5.500	232	4.64	5.500	248	4.96
	5.600	128	2.56	5.600	212	4.24	5.600	224	4.48	5.600	178	3.56
	5.700	98	1.96	5.700	144	2.88	5.700	132	2.64	5.700	162	3.24
	AVERAGE:	154.20	3.08	AVERAGE:	249.00	4.98	AVERAGE:	195.40	3.91	AVERAGE:	241.40	4.83
	STD. DEV.:	59.37	1.19	STD. DEV.:	83.79	1.68	STD. DEV.:	64.34	1.29	STD. DEV.:	114.28	2.29
	COEFFICIENT OF VARIATION (%)	38.50	38.50	COEFFICIENT OF VARIATION (%)	33.65	33.65	COEFFICIENT OF VARIATION (%)	32.93	32.93	COEFFICIENT OF VARIATION (%)	47.34	47.34
	July 28 18:30 Data			July 29 10:30 Data			July 29 16:30 Data			July 30 09:00 Data		
	Station	Beam Rdg	Deflection	Station	Beam Rdg	Deflection	Station	Beam Rdg	Deflection	Station	Beam Rdg	Deflection
	km	mm	mm	km	mm	mm	km	mm	mm	km	mm	mm
SAND SEAL	4.800	124	2.48	4.800	214	4.28	4.800	136	2.72	4.800	132	2.64
COLD MIX	4.900	270	5.40	4.900	350	7.00	4.900	348	6.96	4.900	nr	N/A
	5.000	152	3.04	5.000	186	3.72	5.000	208	4.16	5.000	nr	N/A
	5.100	196	3.92	5.100	226	4.52	5.100	220	4.40	5.100	nr	N/A
	5.200	364	7.28	5.200	nr	N/A	5.200	nr	N/A	5.200	nr	N/A
	5.300	476	9.52	5.300	nr	N/A	5.300	nr	N/A	5.300	nr	N/A
	5.400	306	6.12	5.400	nr	N/A	5.400	nr	N/A	5.400	nr	N/A
	5.500	270	5.40	5.500	224	4.48	5.500	210	4.20	5.500	nr	N/A
	5.600	326	6.52	5.600	242	4.84	5.600	222	4.44	5.600	nr	N/A
	5.700	202	4.04	5.700	180	3.60	5.700	166	3.32	5.700	nr	N/A
	AVERAGE:	268.60	5.37	AVERAGE:	231.71	4.63	AVERAGE:	215.71	4.31	AVERAGE:	N/A	N/A
	STD. DEV.:	105.95	2.12	STD. DEV.:	56.67	1.13	STD. DEV.:	66.43	1.33	STD. DEV.:	N/A	N/A
	COEFFICIENT OF VARIATION (%)	39.44	39.44	COEFFICIENT OF VARIATION (%)	24.46	24.46	COEFFICIENT OF VARIATION (%)	30.79	30.79	COEFFICIENT OF VARIATION (%)	N/A	N/A

Table 4-10 (cont.,)
Southbound Lane, Road 202, TMS Section

	July 30 13:30 Data				July 30 17:30 Data		
	Station	Beam Rdg	Deflection		Station	Beam Rdg	Deflection
	km	mm	mm		km	mm	mm
SAND SEAL	4.800	134	2.68		4.800	146	2.92
COLD MIX	4.900	nr	N/A		4.900	nr	N/A
	5.000	nr	N/A		5.000	nr	N/A
	5.100	nr	N/A		5.100	nr	N/A
	5.200	nr	N/A		5.200	nr	N/A
	5.300	nr	N/A		5.300	nr	N/A
	5.400	nr	N/A		5.400	nr	N/A
	5.500	nr	N/A		5.500	nr	N/A
	5.600	nr	N/A		5.600	nr	N/A
	5.700	nr	N/A		5.700	nr	N/A
	AVERAGE:	N/A	N/A		AVERAGE:	N/A	N/A
	STD. DEV.:	N/A	N/A		STD. DEV.:	N/A	N/A
	COEFFICIENT OF VARIATION (%)	N/A	N/A		COEFFICIENT OF VARIATION (%)	N/A	N/A

4.4.3 Deflection vs. Payload at Various Stations

4.4.3.1 Test Road 103

Figures 4-26 through 4-28 depict plots of deflection vs. payload for several individual stations along Test Road 103. As was noted in several preceding sections, there does not appear to be a consistent trend of greater deflections as the payload increase for either the high or low tire pressure lanes on this road. At an equal payload, most of the sections showed a higher deflection in the northbound lanes, however in some instances the deflection appeared to be higher in the southbound lane.

4.4.3.2 Test Road 202

Figures 4-29 through 4-32 show the deflection vs. payload for several stations for the northbound and southbound lanes of Test Road 202. Once again, based on payload, there is no significant trend for higher deflection with increasing payload.

5.0 DISCUSSION OF TEST RESULTS

5.1 Dynamic Cone Penetrometer Tests

The dynamic cone penetrometer test is a continuous measurement of force required to shear the soil with depth. The test is a relatively simple test that can be conducted quickly. Very little difference was noted in the pre-trial DCP measurements and the post-trial DCP measurements (Figures 4-5 and 4-6) for Test Road 103. A slight softening was noted between pre- and post-measurements on Test Road 202 (Figures 4-13 and 4-14). However, the greatest amount of differential softening was noted in the SBL of Test Road 202 which carried the low tire pressure trucks loaded to primary highway loads. This lane did not exhibit the largest amount of failures, thus it does not appear that DCP is a good indicator of shear failure.

The DCP test measures the strength in the soil in a relatively small column directly around the point of the instrument. As such the strength can be greatly affected by small anomalies such as pebbles or soft particles in the subgrade. It is also impossible to repeatedly test exactly the same point as the trial progresses.

The trials did not conduct a statistical validation of the DCP test. An analysis of the expected variability was extracted from the post-test DCP's conducted on Test Road 103 and reported in Figure 4-7 and 4-8. This testing supplies some degree of confidence in the repeatability of any DCP test. If the test results appear to have a standard deviation from test to test of about 3 mm/blow. Any variability within about ±2 standard deviation should not be attributed to the changes caused by environment or traffic.

As a general observation, DCP testing conducted at the Big Quill site showed that the upper 150 to 200 mm layer was harder than the underlying material. This upper layer had a penetration of 5 to 8 mm/blow at the top of the layer (hard) and gradually increased to 15 to 20 mm/blow at the bottom of the layer. Below this upper layer a softer material generally 20 to 30 mm/blow was encountered to the limit of testing. The majority of roadway failure occurred in the outer wheelpaths. DCP tests were carried out in the outer wheelpaths. Based on the analysis presented in this section, the DCP tests did not indicate a significant change in material strength during the trials. Thus, it is likely that the location of failures was within the lower soft layers or some property of the soil was changing that could not be measured by the DCP (i.e. a physical break-up of crust or increase in pore pressure).

5.2 Benkelman Beam Testing

The Benkelman Beam measures the overall strength of the roadbed. The test is conducted by inserting a probe between the dual wheels on one side of a loaded parked truck. When the truck is driven away, the Benkelman Beam records the rebound of the surface. The Benkelman Beam test was developed for pavements and literature related to Benkelman Beam testing on gravel surfaces is limited.

There are several difficulties with measuring Benkelman Beam deflections on gravel surfaces. The probe of the beam can be greatly affected by individual stones embedded in the surface of a gravel road. Gravel roads are inherently variable. Thus wet pockets, hard spots, etc. result in a large differential reading between successive points tested. In addition, time of day, weather conditions, etc. may affect the reading.

With respect to the Benkelman Beam testing conducted on the Big Quill trials the following comments are provided.

1. Generally on Test Road 103 the deflections increased dramatically shortly after the start of trafficking. After this initial increase the deflections appeared to be very erratic resulting in highs and lows that, at times, were equal to the pre-traffic deflection levels (Figures 4-18 and Figure 4-20).
2. On Test Road 202 the deflections increased shortly after the start of trafficking. However, after this increase no definable trend of increasing beam readings with increasing traffic was noted (Figures 4-22 and Figure 4-24).

6.0 VISUAL OBSERVATIONS

The following sections discuss the visual observations on the two Big Quill test roads as obtained from viewing the videos taken during the trials. No video logs were available for the Walpole test roads.

6.1 Test Road 103

This test road received trafficking from identically loaded trucks in the north and southbound lanes. The northbound trucks were 9-axle semi's loaded to the permitted primary highway weights using high tire pressures. The southbound trucks were the same vehicles as the northbound, however when operating southbound the tire pressures were reduced to 80 psi on tires of the steering axle, 60 psi on tires of the driving axles and 50 psi on tires of the trailer axles.

The series of photos attached as Photo 6-1 to 6-20 show the following progression of failure.

Trafficking started near noon on July 26, 2000 with high tire pressure trucks driving on Loop 2. By approximately 6:30 p.m. the northbound lane of the test road had been subjected to 70 passes (see Photos 6-2 and 6-12). By this time the TMS section of the test road exhibited severe damage with outer wheelpath rut/shear failure throughout. Other short sections of the road also showed some failures.

At 7:00 a.m. on July 27, tire pressures were lowered and trafficking commenced on Loop 1. By 7.00 p.m., 140 passes of the trucks with low tire pressures had trafficked the southbound

lane (see Photos 6-3 and 6-13). Some breakouts were noticeable but the extent of break-up was considerably less than in the high tire pressure lane after 70 passes. For the morning of July 28 the trucks increased the tire pressure and again ran on Loop 2. By noon on July 28, 2000, each lane had carried 140 truck passes (see Photos 6-4 and 6-14). The high tire pressure lane was considerably more cracked and failed than the low tire pressure lane after the same number of passes. The trucks continued to operate at high tire pressure until 7:22 p.m. on July 28, at which time the northbound lane had carried 200 passes (9348 t) and was considered unpassable as it was extensively failed (see Photos 6-6 and 6-16). The trucks reverted to low tire pressure on Loop 1 on July 29th. By noon on July 29, 2000 each lane had carried 200 identical loads.

Low tire pressure trucks continued to operate Loop 1 through July 29, 30, 31 and August 1, 2000. By 3:00 p.m. on August 1 a total of 721 trucks with low tire pressure had travelled the loop. The low tire pressure lane appeared to be severely broken up but at no time did the ruts/shear failures appear to be as severe as the failures in the northbound (high tire pressure) lane. It should be noted that certain sections of roadway, most notably the southern most 500 to 600 m of Test Road 103 showed no signs of failure in either lane.

Throughout the trials the loaded trucks were requested to stay on their respective sides of centreline. Given the approximate 8 m width of roadway the outermost axle was within 1 to 1.5 m of the edge of the road.

While the main test road failed severely in the outer wheelpaths in both directions, it is notable that only minor failures developed in the loop roads. The loop roads were, in some instances, of a much lower quality than the test road. Discussion with the truckers noted that on the loop roads the truckers could operate closer to the centre of the road and vary their speed and truck position to avoid developing failures. These factors are therefore, obviously, important to preventing failures.

6.2 Test Road 202

This test road received trafficking from trucks loaded to the secondary highway legal loads with high tire pressure (100 psi) in the northbound lane (Loop 4). In the southbound lane (Loop 3) the trucks were loaded to the permitted primary highway loads and they operated with tire pressures of 80 psi on the steering axle, 60 psi on the driving wheels and 50 psi on the trailer axles. Section 1.2 provides the individual truck or axle weights. It should be noted that the remainder of this section refers to total payload carried. However, the low

tire pressure trucks have a higher efficiency in terms of less tare weight per tonne of payload. The low tire pressure trucks have approximately .5 tonnes of tare weight per tonne of payload and the high tire pressure trucks have 0.58 and 0.63 tonnes of tare weight per tonne of payload depending on the type of truck.

Trafficking commenced at approximately noon on July 26, 2000, the same time as for Test Road 103. Both high and low tire pressure trucks were operating at the same time. For safety reasons the trucks were controlled so that only one set of trucks was allowed on the test road at one time. Both sets of trucks were instructed to stay on their own side of centreline. Since Road 202 was narrower and of a lower standard than Road 103, failures developed sooner.

By 7:50 p.m. on July 26, 2000, 80 low tire pressure passes and 126 (72 8-axle trucks and 54 6-axle trucks) high tire pressure passes had been conducted on the test road. However, the total payload was approximately equal with 3782 tonnes southbound and 3702 tonnes northbound. By this time the TMS had failed extensively (90%) under the high tire pressure and several other failures had developed in the gravel sections mainly in the northbound, high tire pressure lane. In order to keep vehicles travelling on this test road it became obvious that maintenance was required. The TMS on the low tire pressure lane showed that 40% of the surface had failed. In most cases, 10% failure would be considered as complete road failure, thus for both lanes of the TMS the road could be considered 'failed'.

By the end of July 27, 150 low tire pressure trucks and 238 high tire pressure trucks (136 8-axle trucks and 102 6-axle trucks) had trafficked the test road. However, payload once again was almost equal with 7093 tonnes southbound and 6994 tonnes northbound. Maintenance was being conducted nearly continuously. The high tire pressure lane was failing more quickly than the low tire pressure lane. Trafficking and maintenance continued through July 29 and 30 until 380 low tire pressure (17,970t payload) and 478 high tire pressure (13,634t payload) vehicles had travelled on the test road.

Once again while the test road failed extensively the loop roads held up well. In fact, one loop road 1.6 km west of the test road was expected to fail because of its low gradeline and narrow width. However, the low tire pressure vehicles used this roadway for the entire trial with no major failures.

7.0 MODELLING

The following summarizes results of analytical studies carried out to assist in quantifying possible failure mechanisms as observed in the field.

7.1 Static Analysis

7.1.1 DAMA Analysis

The DAMA computer program (developed by AASHTO from the CHEV5L program) was used to predict the stresses under wheel loads for various tire pressures. Figures 7-1 through 7-3 show the approximately stresses below a static wheel load with various tire pressures. The main variable between these figures is the amount of pavement structure included. Figure 7-1 has a 6.5" pavement structure (as was placed on Hwy 6 in the vicinity of the test section), Figure 7-2 has a 1" pavement structure (as is typical of a TMS), and Figure 7-3 has a 0.1" pavement structure (computer program will not allow for no pavement). In all cases, as the tire pressure decreases the stress at surface decreases as well. By some depth below surface the stresses are exactly the same regardless of the tire pressure. For the very thin structure this point of equal stress is about 16" (400 mm) below surface.

7.1.2 Other Static Analysis

EBA analyzed the deflection bowl that was measured on Road 202 under the Benkelman Beam truck. Figure 7-4 shows the results of the analysis performed and includes the measured deflection bowl. The 3-layer system used a 100 mm (4") surficial layer with a modulus of 98 MPa (14,800 psi), an intermediate layer of 100 mm (4") with a modulus of 50 MPa (7200 psi) and a lower layer of 29 MPa (4200 psi). This 3 layered system was selected based on the DCP and soil results and shows a relatively good agreement with the measured deflection bowl. The one layer analysis assumed a subgrade modulus of 29 MPa (4200 psi). The one layer analysis was conducted to determine the effect of changing the upper crust layer to a layer no stronger than the lower subgrade layer. When modeling a structure it is generally accepted that a strong surface layer will deteriorate until the strength of the layer approaches the strength of the layer below. When the strength of the layers is equal, the two layers begin to act as one layer. In a layer system the upper layers cannot be weaker than the lower layers. As can be noted in Figure 7-4, the change in total deflection

was minimal as the strength of the upper layers decreased. This would indicate that crust breakdown should not result in large increases in deflection.

In order to determine the sensitivity of the upper layer moduli to the maximum deflection the parametric analysis presented in Table 7-1 was conducted by varying the subgrade moduli and surface moduli for a 200 mm surficial layer.

Table 7-1
Calculated Maximum Deflection mm (inches)

E2 MPa (psi)	E1 MPa (psi) (Surface Layer)			
	34.5 (5,000)	69.0 (10,000)	138 (20,000)	207 (30,000)
20.7 (3000)	2.55 (0.101)	2.26 (0.089)	1.99 (0.078)	1.82 (0.072)
27.6 (4000)	2.01 (0.079)	1.79 (0.071)	1.58 (0.062)	1.46 (0.057)
34.5 (5000)	1.67 (0.060)	1.49 (0.059)	1.32 (0.052)	1.22 (0.048)

From this analysis it is clear that, as the strength decreased in the uppermost layer (i.e. crust breakdown) the deflection of the roadway should increase by a relatively small amount and would be a maximum of 20 to 25%. Thus, some other mechanism must be used to account for the change of deflection of 50 to 100% as was noted during the trials.

One possible mechanism that could cause increased deflections would be an increase in porewater pressure (saturated soils) or a decrease in soil suction (unsaturated soils). The pumping action of the frequent trucks could be causing the porewater increases. Porewater pressure increases would dissipate shortly after truck haul ceases for the day. After the loads have ceased for a day the soils (and deflection) would tend to return to their pre-traffic condition. Figures 7-5 to 7-8 show the measured deflections in the north and southbound lanes for both Test Road 103 and 202 with the superimposed deflection increases and decreases as postulated above. As can be noted the variability of the deflection increase combined with the small number of data points results in a very rough correlation of deflection versus time. It should be pointed out that this correlation cannot be verified by statistics because of the large influence of the dynamic portion of the deflection change in relation to the small change caused by the crust breakdown.

However, if this mechanism is correct, then deflections would increase as a function of how the traffic is applied. On days with interruptions in traffic for maintenance, the soil would have an opportunity to dissipate the pressure build up and overall deflection would be reduced. The results as measured would be influenced by the accelerated nature of the trial. This hypothesis would indicate that a concentrated truck haul carrying a given tonnage of

goods would be more damaging to the road than moving the same tonnage of goods over a longer period.

When the Walpole trial was compared to the Big Quill trials, it was obvious that much lower damage was noted at the Walpole site. The DCP testing indicated that the soils at the Walpole trial site were stronger than the soils at the Bill Quill trial site. However, the soil types at Walpole were very similar to the Big Quill site. The increased strength at Walpole does not account for the fact that the roadway at the Walpole site carried 420 loaded trucks with no appreciable damage and the damage at the Big Quill site was obvious before 70 loaded trucks had travelled over the roadway.

To further expand the discussion of the influence of pore pressure on deflection the following points are provided.

1. When the first truck passes over a point in the roadway the deflection under the wheels cause some distress/cracking as well as a densification of the soil particles. It is possible that no net pore pressure increase would occur after one pass. It may take several passes to induce pore pressure build-up. In the case of lower tire pressures, the stress in the surface layers would be less than for high tire pressures and therefore the porewater pressure build-up in the surface layers is reduced (see Figures 7-1 and 7-3).

2. If a second truck passes over the same point in the roadway approximately the same deflection under the wheels would occur. As this process is repeated at some point the pore pressures would start to increase.

3. If the distance/time between load applications is large the pore pressure would dissipate after each application and no increase in deflection would occur.

4. If the distance/time between load applications is small the pore pressure would increase slightly after each application. As the pore pressure increase is directly related to tire pressure the pore pressure increase would be slower under low tire pressures.

5. After haul stops, for any reason, the dissipation of pore pressure would be a function of soil properties such as permeability. For a soil with low permeability the pore pressure would decrease slowly, for a high permeability the pore pressure would decrease quickly.

6. The mechanism explained above appears to model the performance on the two Big Quill test roads fairly well. In the high tire pressure lane of Test Road 103 the deflections were only measured three times after haul started. One set of measurements was conducted late on July 26, 2000 shortly after 70 trucks had travelled the road in 5 hours. A second set of readings was taken at approximately noon on July 28 after an additional 70 trucks had travelled over the road in 5 to 6 hours. The third set of readings was obtained late on July 28, after an additional 60 trucks had travelled over the roadway. The deflections measured after 70 trucks on July 26 was approximately equal to the deflection measured on July 28 after a further 70 trucks had travelled over the roadway. The same type of pattern appears to apply to the southbound lane on Test Road 103 and both lanes on Test Road 202.

7. Any detailed comparisons of number of loads and deflection must be considered in light of the pauses and breaks in the haul traffic that were a result of stopping to obtain the deflection/DCP readings. Whenever the traffic was stopped the pore pressures would begin to dissipate. It is not clear from the data available the time required to dissipate the pore pressures, however, if the break to obtain the readings was long enough to allow pore pressures to dissipate entirely, the readings of deflection could be suspect because as the pore pressure dissipates the deflection would decrease. Thus, deflections obtained shortly after truck haul stopped would be greater than deflections obtained one half or one hour later.

8.0 SUMMARY OF MAJOR CONCLUSIONS

Based on the two trials carried out by Saskatchewan Highways and the analysis that has been presented in this report, the following major conclusions can be provided.

1. The ability of trucks to wander on the road surface and adjust their speed and position can significantly decrease damage to the roadway regardless of tire pressure.

2. The weakest area of the roadway is the shoulder area and when trucks are travelling close to the edge of the roadway the greatest damage occurs.

3. In a concentrated haul situation, low tire pressure causes less damage than high tire pressure on gravel and TMS roadways.

4. Based on theoretical calculations, a conventional pavement structure that has competent materials in the upper layers will have identical stresses in the subgrade regardless of high or low tire pressure.

5. The deflection of a gravel roadway is influenced by both a structural breakdown as well as a secondary influence. In this report, pore pressure build-up has been used as the explanation for the secondary influence. If pore pressure build-up is the cause of some of the increased deflection then soil properties will influence the rate of pore pressure dissipation.

9.0 POLICY CONSIDERATIONS

EBA has been requested to comment on the following policy considerations:

1. How applicable is low tire pressure for the various road standards that exist in Saskatchewan? i.e. pavements, thin membrane surfaces, super grids, grids, main farm access, municipal roads, basic access roads and prairie trails.

   As a general rule low tire pressure exerts a lower stress within the materials below the tire. Therefore, in no instance will low tire pressure be more destructive than an equivalent load at high tire pressure. However, when competent materials compose the uppermost layers of the pavement, the difference between damage caused by high and low tire pressure decreases. In the case of a hot mix layer over granular layers, there is likely no difference in performance. However, as the strength and thickness of the pavement layers decreases low tire pressure will result in much less damage than high tire pressure for a given load.

2. How effective is low tire pressure as a damage mitigating measure on all of the various road standards as compared to other factors that could be employed such as reduced vehicle speed and lower axle and gross vehicle weights?

   As noted, low tire pressure is more effective on roads without competent surfacing structures (such as gravel roads) than roads that have been paved with a competent surfacing structure. For paved roads reduction in axle and gross vehicle weights would likely be more effective in controlling damage than tire pressure. However, based on the concentrated haul of the Big Quill sites, low tire pressure is much more effective as

a damage mitigating measure than axle and gross vehicle weight for grid or main farm access roads.

The issue of controlling speed as a method of limiting damage is not well defined in this study. However, based on the literature study, reducing speed reduces the impact loading once failures have developed. Reducing tire pressure accomplishes much the same impact reduction by providing an extra level of shock/impact protection. For pavements, slowing the trucks increases the loading time which is known to decrease asphalt stiffness. Thus, theoretically, reducing vehicle speed on a pavement increases the stresses in the subgrade. However, this stiffness reduction is generally considered important only for gross vehicle speed changes, such as slow stop and go city traffic versus highway speeds. It would not likely have a significant effect between 70 and 100 km/hour which is likely range of speed control that could be implemented to control damage to a highway. The following table presents a brief summary of the effectiveness in mitigating damage by axle weight, tire pressure and speed.

	Mitigating Measure		
	Reduced Weight	**Low Tire Pressure**	**Lower Speed**
Pavement	most effective	somewhat effective	detrimental
TMS			effective
Grids			
Main Farm			
Access			
Municipal Roads			
Basic Access			
Trail	somewhat effective	most effective	most effective

3. On the assumption that road damage can occur very quickly, what measures should road authorities employ to manage their road infrastructure to cope with the significant problems associated with the dramatic increase in trucking activity related to agriculture?

It appears from the analysis in this study that road damage is related to numerous factors which include roadway width, frequency of truck applications, soil type, vehicle load, vehicle speed, tire pressure, season of the year, type and thickness of surfacing structure as well as several other factors.

It is assumed that the road authority cannot react quickly to roadway width, type and thickness of surfacing structure or soil type. However, over the long-term, all of these factors should be carefully considered in all roadway construction/reconstruction.

This means that road authorities have a relatively small number of 'tools in their tool box' to manage their road infrastructure to cope with increasing truck traffic. The following summary of available 'tools' is provided:

a) Controlling/regulating tire pressure. As presented in this report, tire pressure can be very effective in controlling damage on gravel surface roadways. The tire pressure is less effective (but still somewhat beneficial) on paved surfaces.
b) Controlling/regulating axle/vehicle weights. This is usually a provincial government authority and has been used effectively to limit the maximum loads on a pavement. In conjunction with spring bans has been used effectively for pavements. Effectiveness on gravel roads is not clear but clearly reducing tire pressure is more effective than reduced loads.
c) Controlling vehicle speed. This study does not provide direct input on how speed and damage are related. However, based on the literature study, reduced speeds especially on roads showing some damage, will reduce impact load and reduce damage.
d) Controlling number of vehicles on a road. This study appears to indicate that a concentrated haul on some roads will do more damage than the same quantity hauled over a longer period. While controlling frequency of loading may appear to be outside of the control of road agency, there may be an opportunity to work with trucking companies to spread haul on some roads over a longer period. For instance, rather than assigning 3 or 4 trucks to haul all of the grain from one farm to the closest elevator, only one truck could be assigned. Thus, rather than 15 to 20 loads from the farm to the elevator in one day (assuming a 2 hour round trip) the loads would be spread over 3 or 4 days.

4. If possible, quantify the potential benefit of introducing reduced tire pressure at the existing weight regulations.

Based on the information presented in this study, it is not possible to exactly quantify the potential benefit of reducing tire pressure. However, based on the concentrated haul on Test Road 202, it appears that reduced tire pressure at primary highway loads is less damaging than high tire pressure at secondary highway loads.

10.0 RECOMMENDATIONS FOR FURTHER STUDY

This study has identified certain areas where definitive conclusions cannot be derived from the information available. It is suggested that further study be conducted in the following areas.

1. Influence of time between loads on material strength. It is suggested that a laboratory study be conducted to determine the influence of time between loads on material strength. This study must adequately consider the increase in porewater pressure so the test should be conducted in a triaxial cell. Several different soils with different permeabilities and moisture contents should be examined.

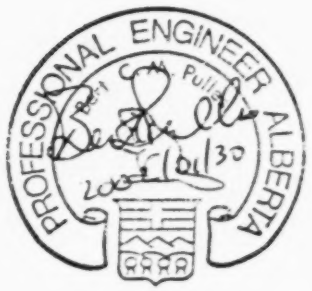
2. Repeatability of Deflection Tests. Based on the information available, the expected variability of a deflection test on gravel surfaces is not well-defined. Because of the lack of information on these tests, it would be beneficial to conduct some trials on the repeatability of Benkelman Beam tests.

11.0 CLOSURE

We trust the information provided meets your present requirements. Please call if you have any questions.

EBA ENGINEERING CONSULTANTS LTD.

Prepared by:



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PHOTOS

Photo 6-1 Station 3+240 Southbound - Low Pressure Lane - 70 passes

Photo 6-2 Station 3+240 Northbound - High Pressure Lane - 70 passes

Photo 6-3 Station 3+240 Southbound - Low Pressure Lane - 140 passes

Photo 6-4 Station 3+240 Northbound - High Pressure Lane - 140 passes

Photo 6-5 Station 3+240 Southbound - Low Pressure Lane - 200 passes

Photo 6-6 Station 3+240 - Northbound - High Pressure Lane - 200 passes
(end of high pressure haul)

Photo 6-7 Station 3+240 Southbound - Low Pressure Lane - 267 passes

Photo 6-8 Station 3+240 Southbound - Low Pressure Lane - 512 passes

Photo 6-9 Station 3+240 Southbound - Low Pressure Lane - 645 passes

Photo 6-10 Station 3+240 Southbound - Low Pressure Lane - 721 phases (end of low pressure haul)

Photo 6-11 Station 3+500 Southbound - Low Pressure Lane - 70 passes

Photo 6-12 Station 3+500 Northbound - High Pressure Lane - 70 passes

Photo 6-13 Station 3+500 Southbound - Low Pressure Lane - 140 passes

Photo 6-14 Station 3+350 Northbound - High Pressure Lane - 140 passes

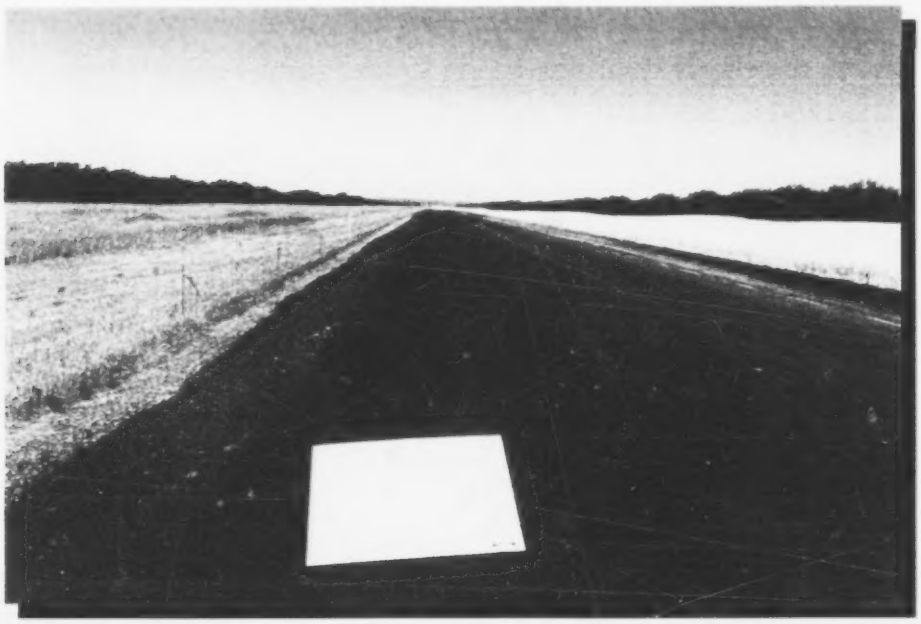


Photo 6-15 Station 3+500 Southbound - Low Pressure Lane - 200 passes

Photo 6-16 Station 3+500 Northbound - High Pressure Lane - 200 passes (end of high pressure haul)

Photo 6-17 Station 3+500 Southbound - Low Pressure Lane - 267 passes

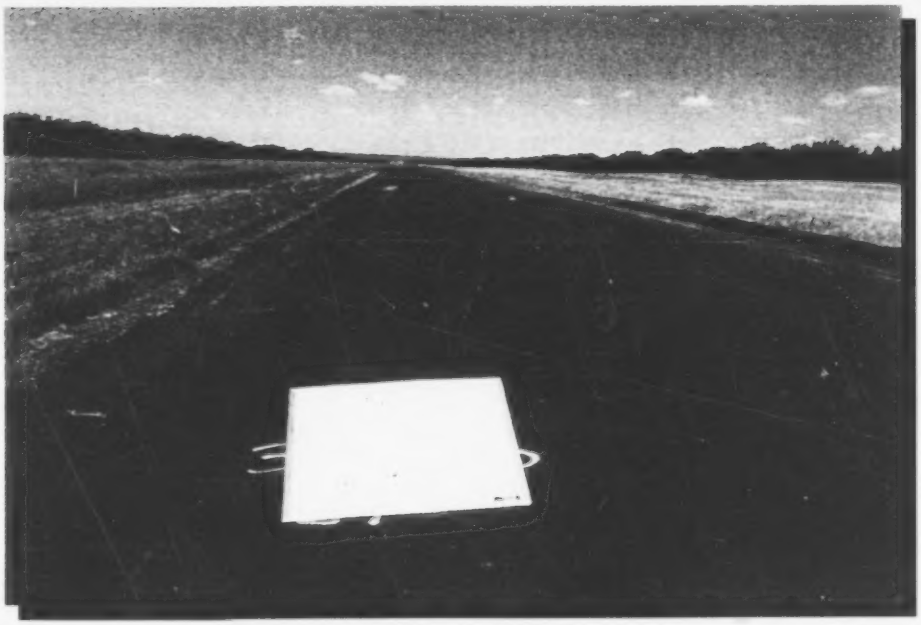


Photo 6-18 Station 3+500 Southbound - Low Pressure Lane - 512 passes

Photo 6-19 Station 3+500 Southbound - Low Pressure Lane - 645 passes

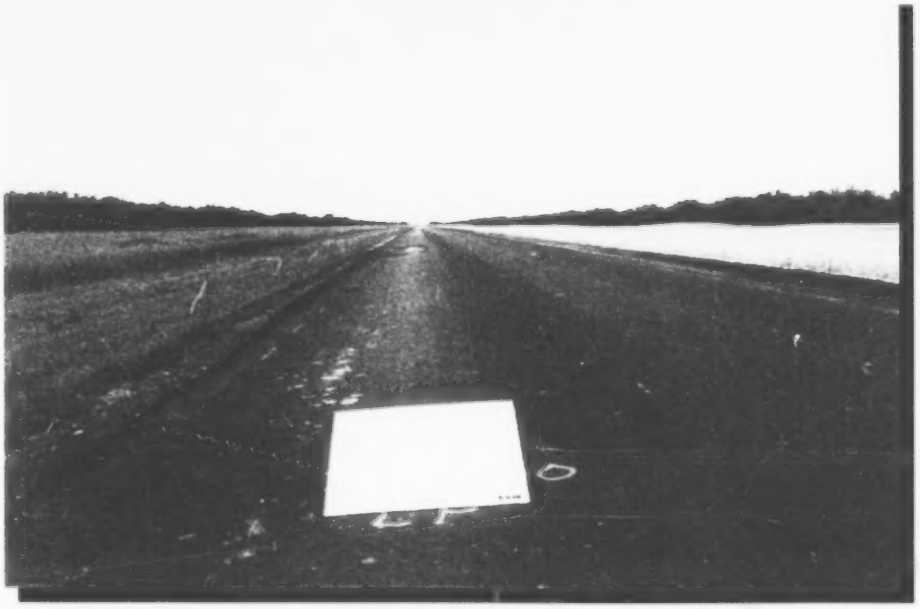


Photo 6-20 Station 3+500 Southbound - Low Pressure Lane - 721 passes (end of low pressure haul)

FIGURES

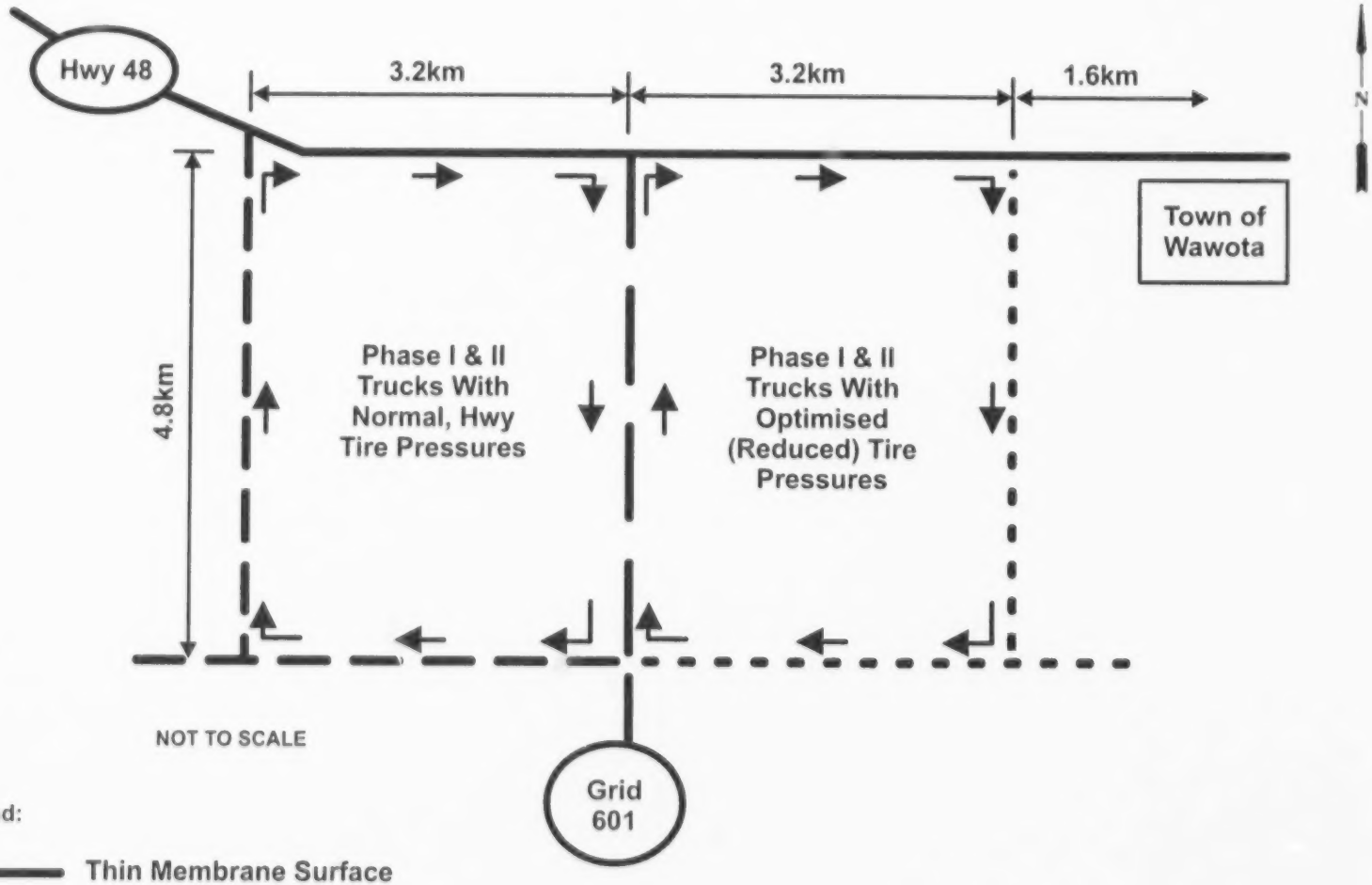


Figure 1-1
Walpole Trial Site

Figure 1-2
Washboard Severity for Low and High Tire Pressure
(After Approximately 220 Empty Truck Passes)

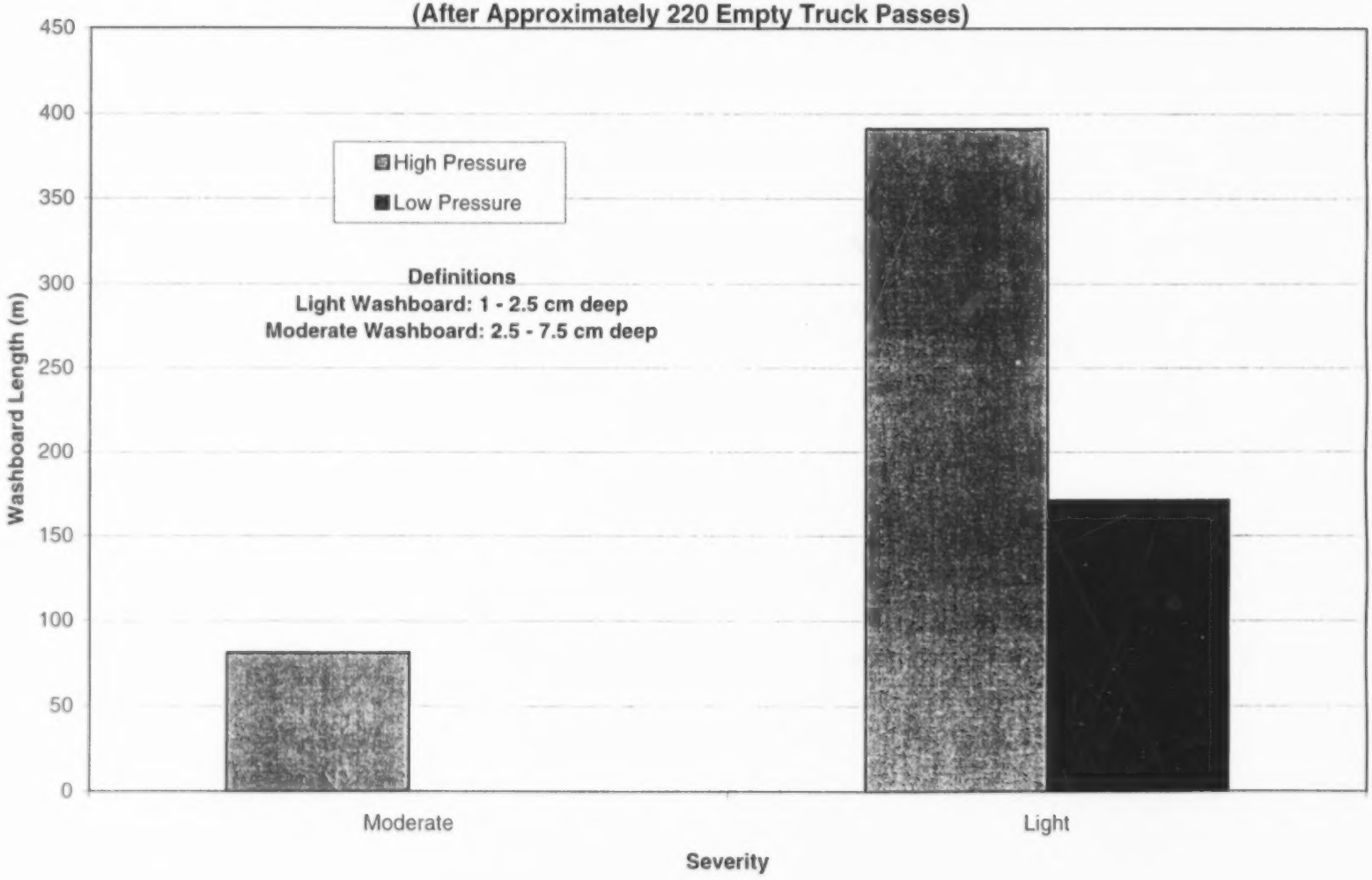


Figure 1-3

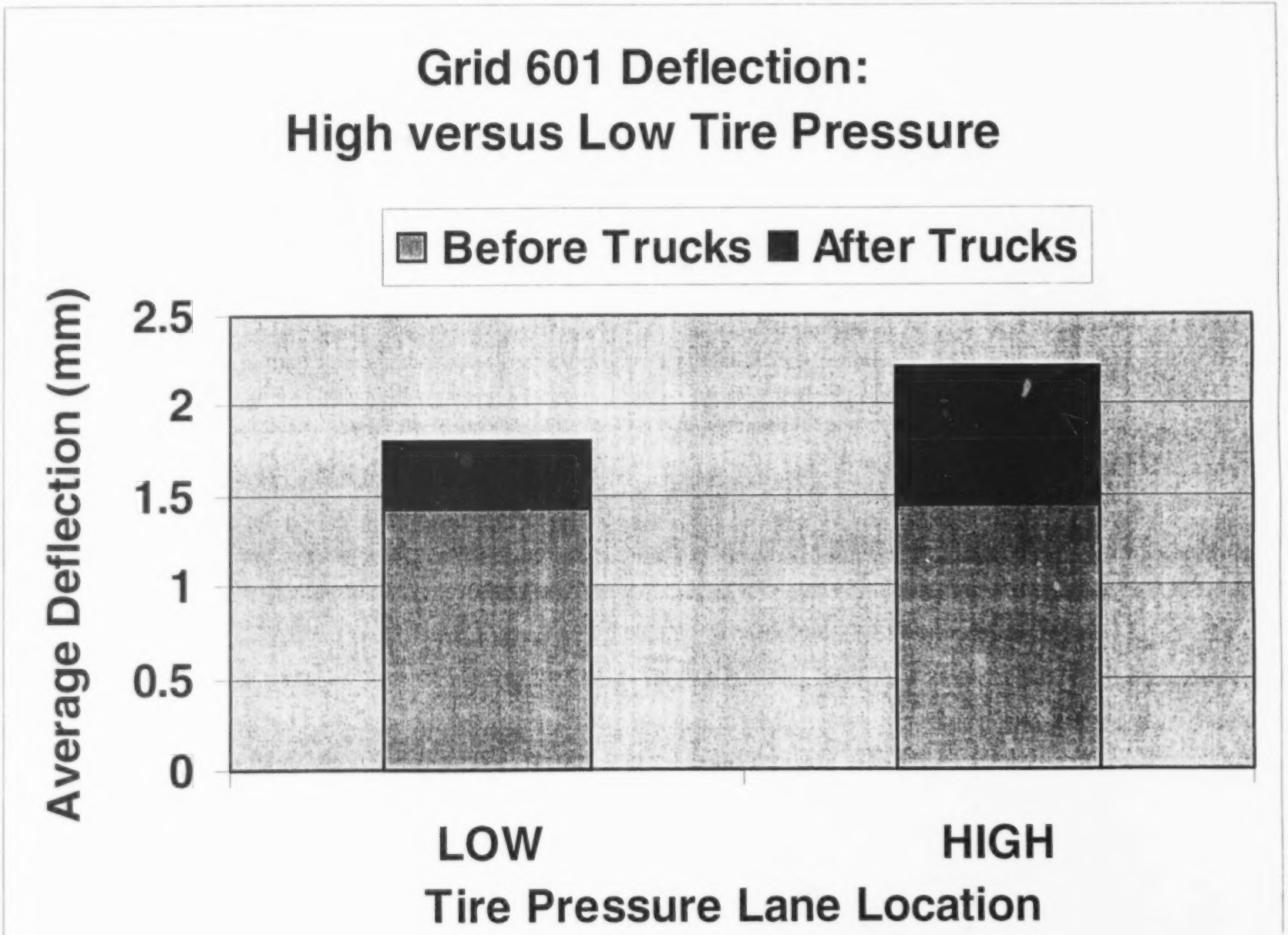

Grid 601 Deflection:
High versus Low Tire Pressure
Before Trucks
After Trucks
Average Deflection (mm)
2.5
2
1.5
1
0.5
0
LOW
HIGH
Tire Pressure Lane Location

Figure 1-4

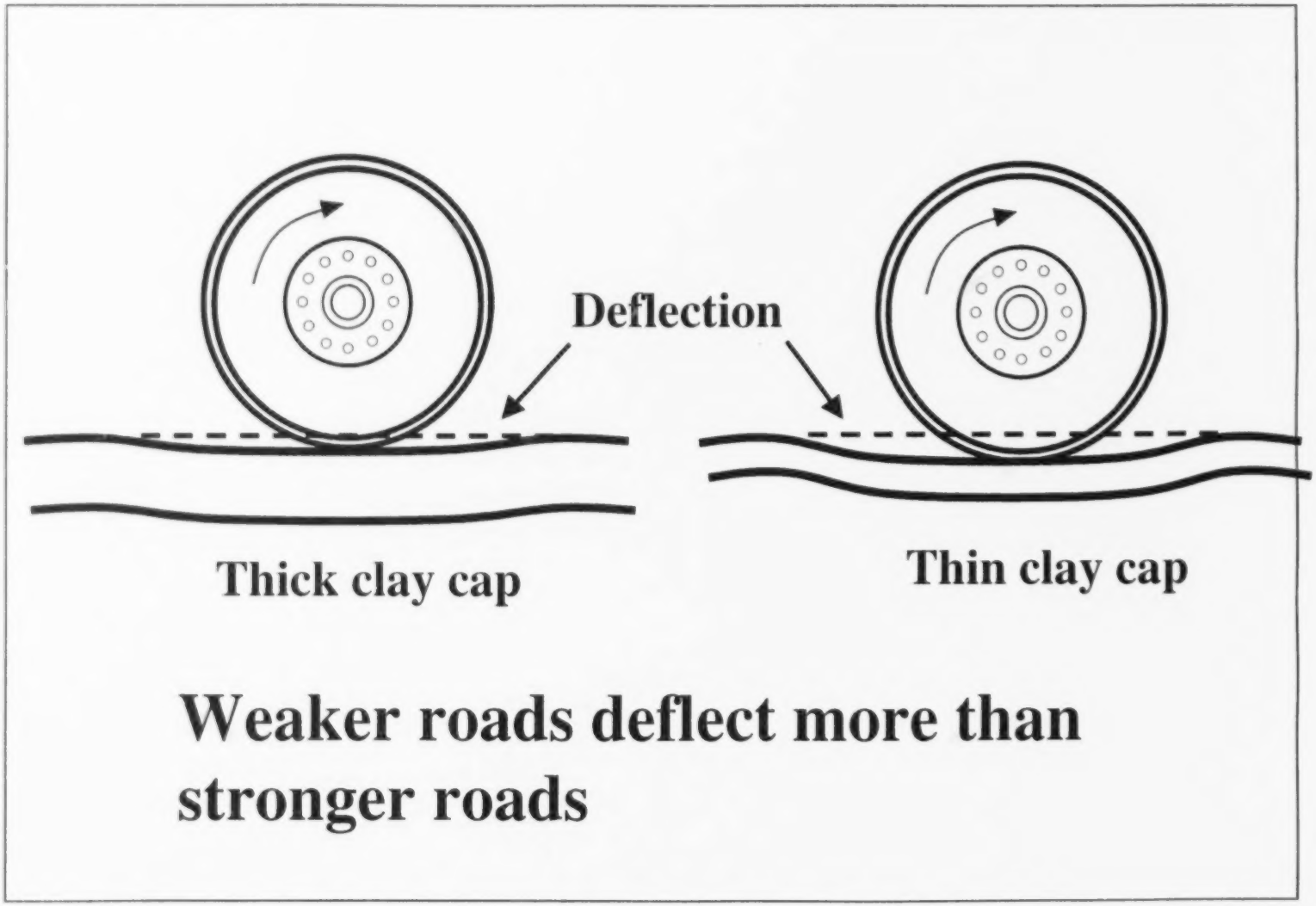

Deflection
Thick clay cap
Thin clay cap
Weaker roads deflect more than stronger roads

Figure 1-5

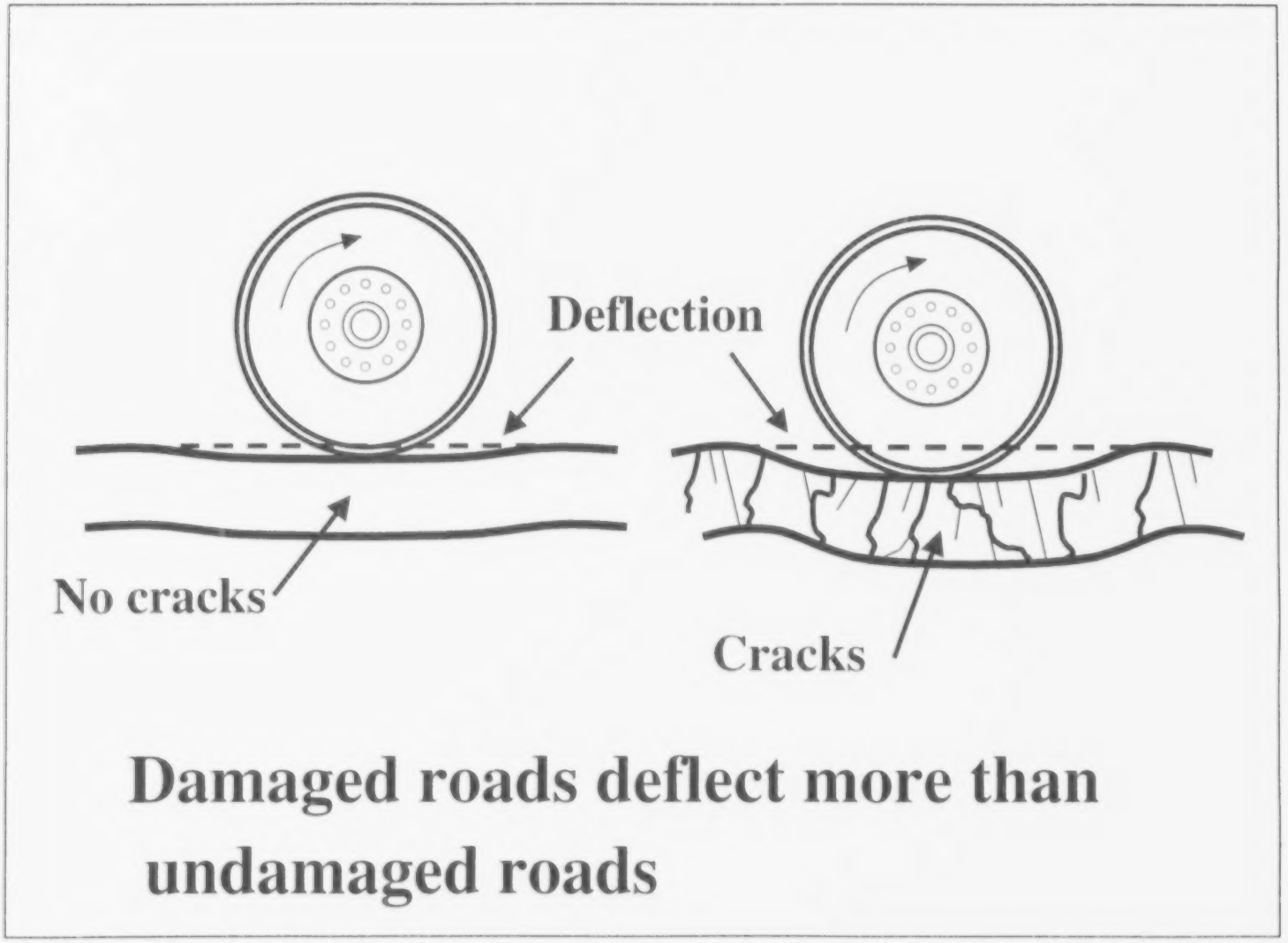

Deflection
No cracks
Cracks
Damaged roads deflect more than undamaged roads

Figure 1-6

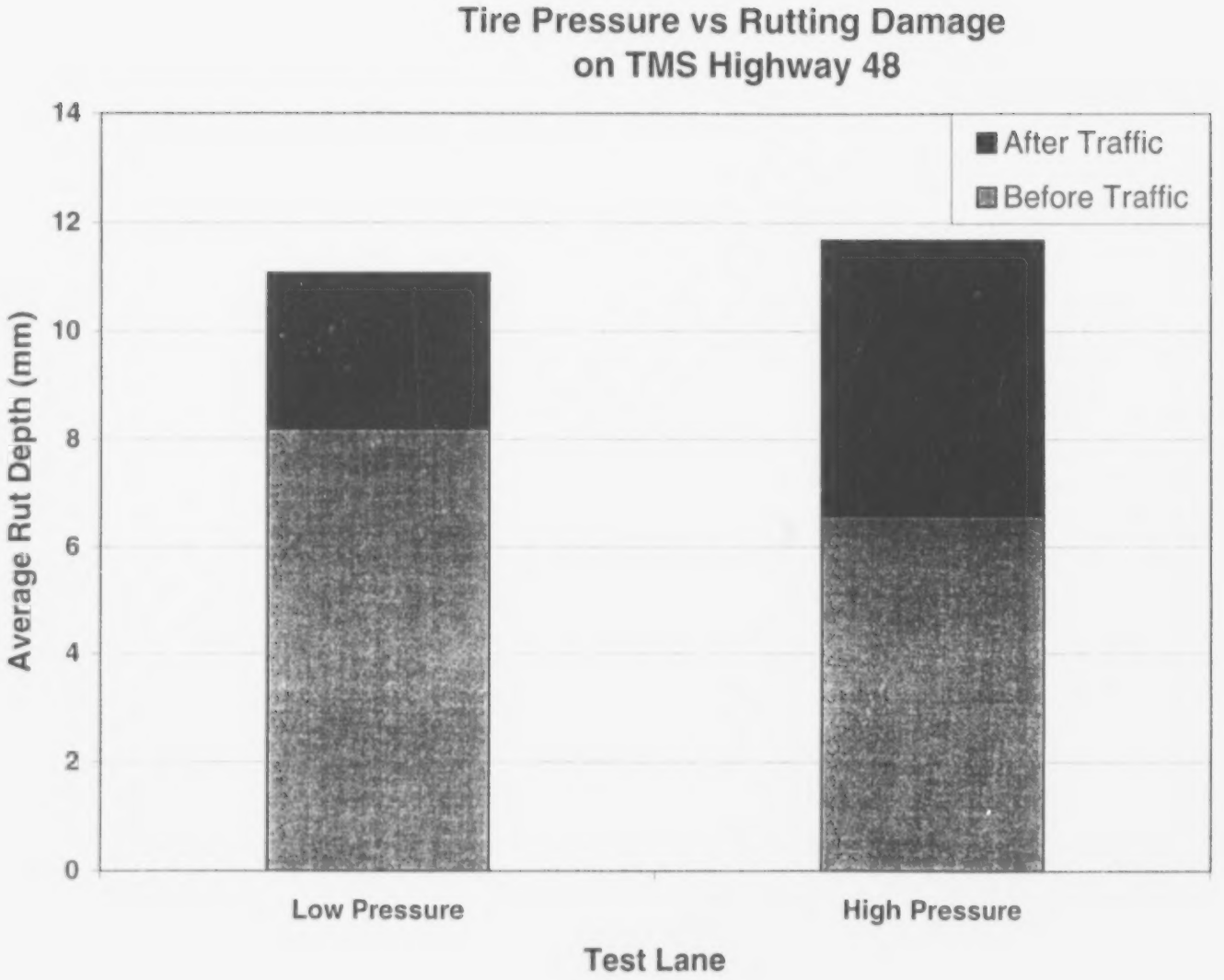
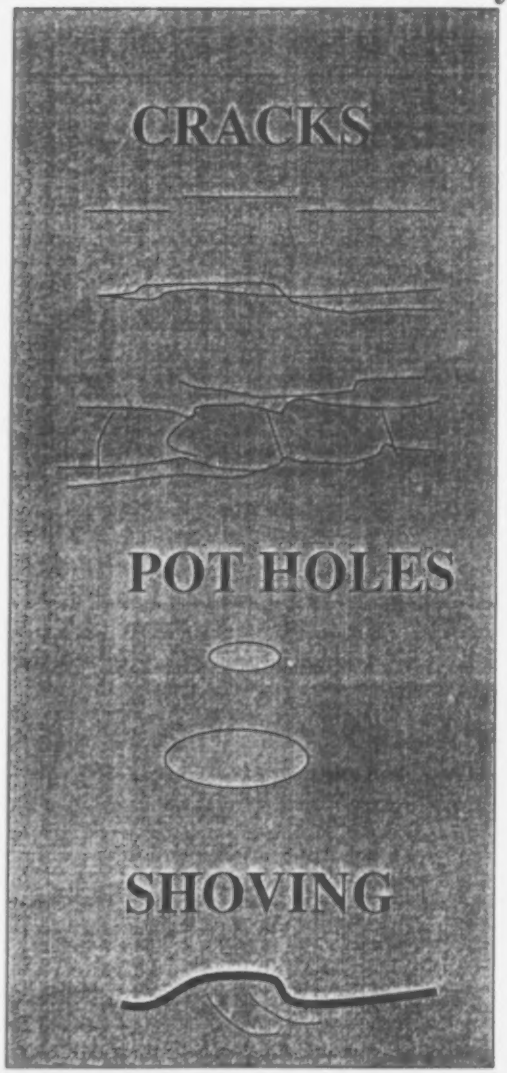

Tire Pressure vs Rutting Damage
on TMS Highway 48
After Traffic
Before Traffic
Average Rut Depth (mm)
0
2
4
6
8
10
12
14
Low Pressure
High Pressure
Test Lane

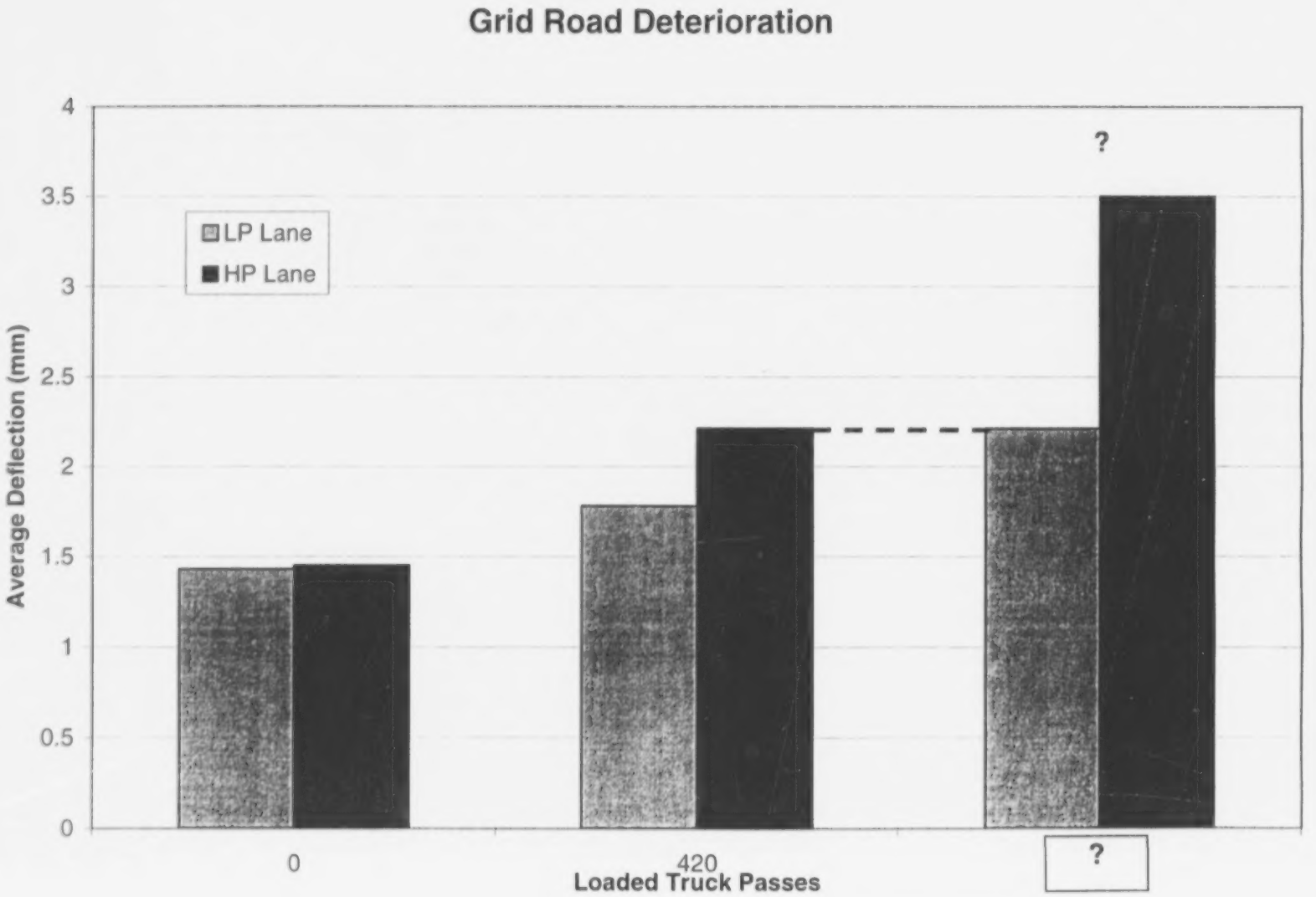
Figure 1-7

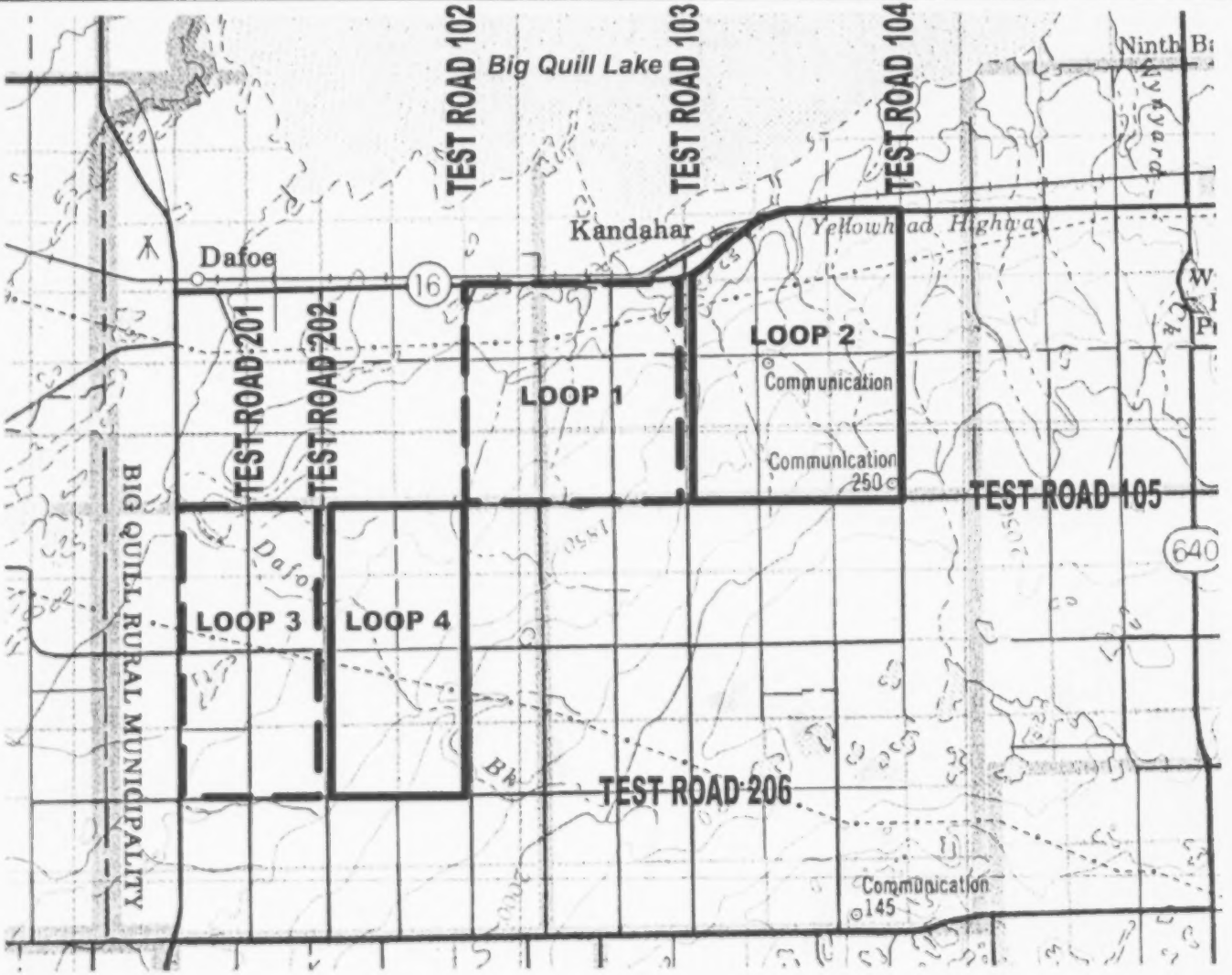
Summary of Surface Damage to TMS Highway 48



	HIGH PRESSURE	LOW PRESSURE
Light	7 m	93 m
Moderate	47 m	125 m
Heavy	173 m	104 m
Severe	33 m	3 m
Small	5/5 shallow/deep	10 shallow
Large	2 deep	0 deep
	91 m^2	16 m^2

Figure 1-8


Grid Road Deterioration
Average Deflection (mm)
4
3.5
3
2.5
2
1.5
1
0.5
0
LP Lane
HP Lane
?
0
420
?
Loaded Truck Passes



NOT TO SCALE

Figure 1-9
Big Quill Trial Site

Figure 1-10
Equal Axle Weights Gravel Test Road 103

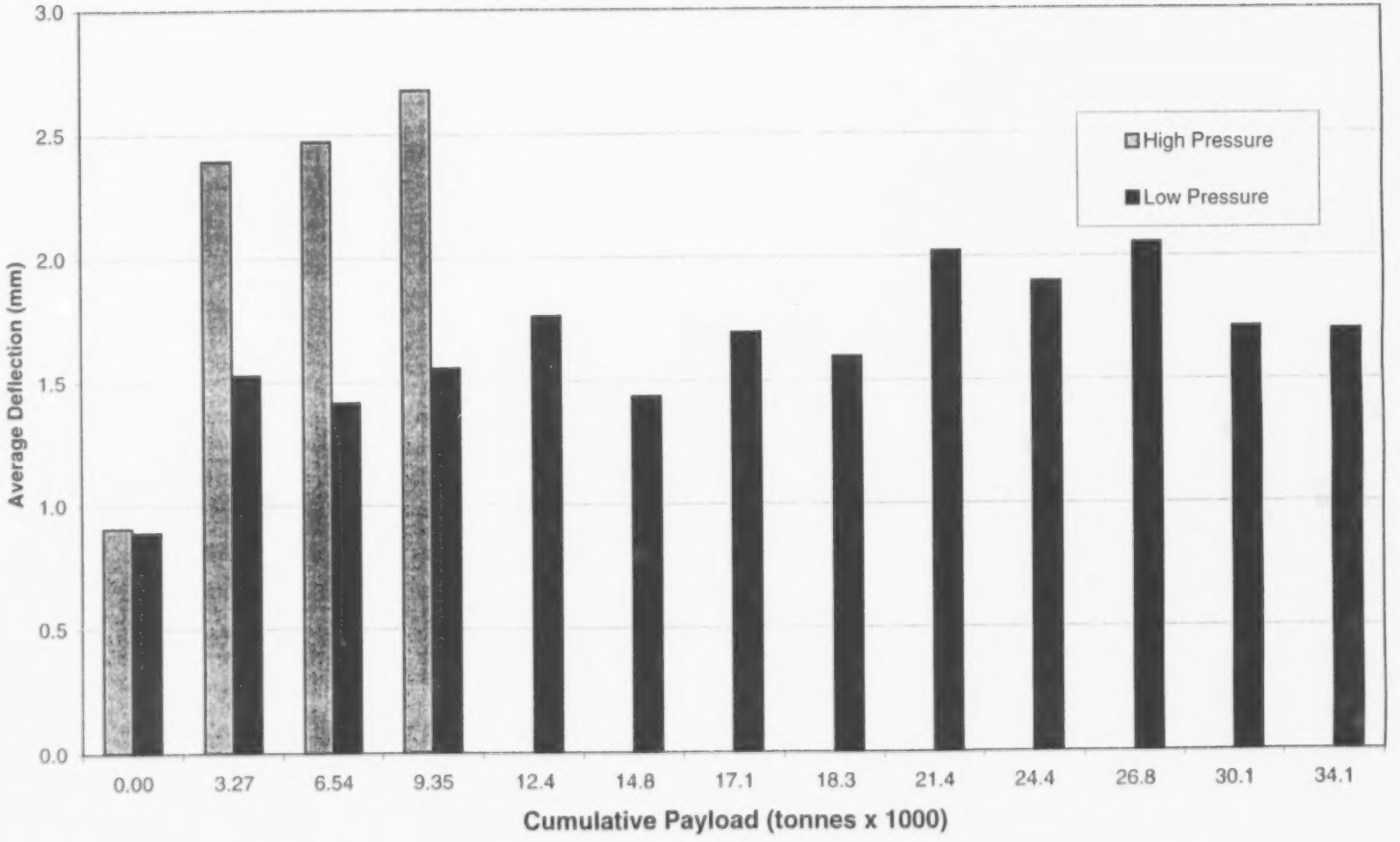


Figure 1-11

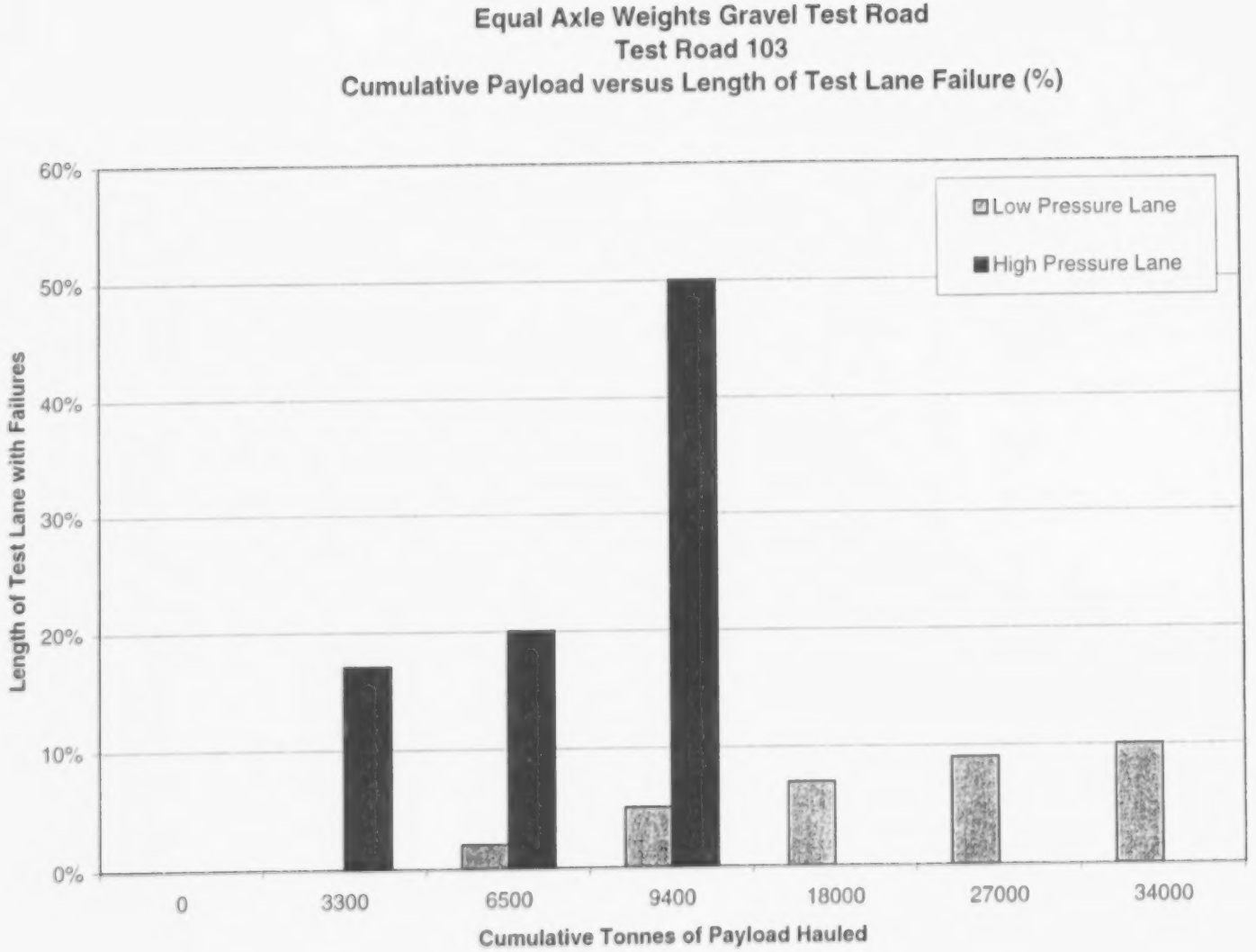

Equal Axle Weights Gravel Test Road
Test Road 103
Cumulative Payload versus Length of Test Lane Failure (%)
Low Pressure Lane
High Pressure Lane
Length of Test Lane with Failures
60%
50%
40%
30%
20%
10%
0%
0
3300
6500
9400
18000
27000
34000
Cumulative Tonnes of Payload Hauled

Figure 1-12

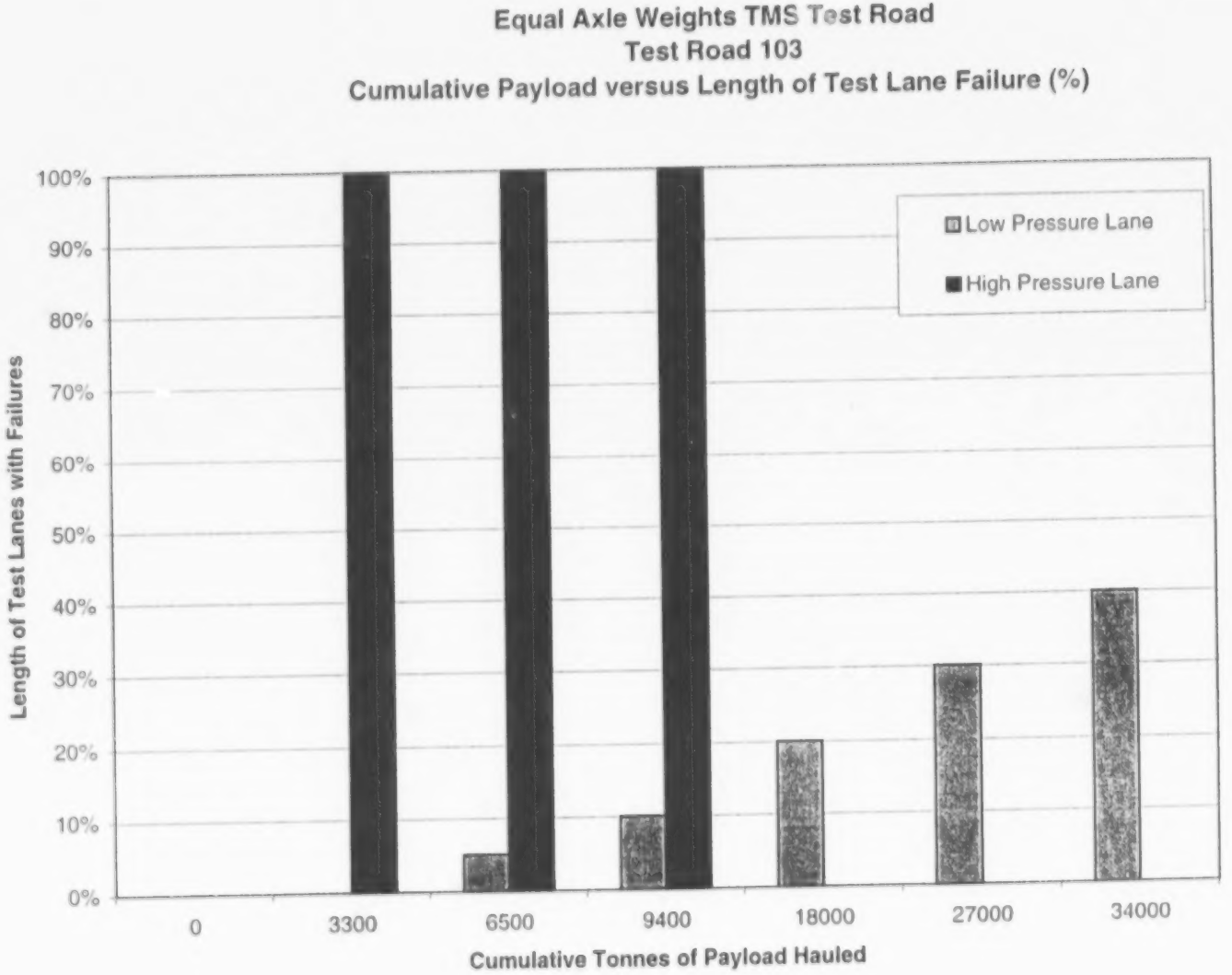

Equal Axle Weights TMS Test Road
Test Road 103
Cumulative Payload versus Length of Test Lane Failure (%)
Length of Test Lanes with Failures
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Low Pressure Lane
High Pressure Lane
0
3300
6500
9400
18000
27000
34000
Cumulative Tonnes of Payload Hauled

Figure 1-13
Equal Payloads Gravel Test Road 202

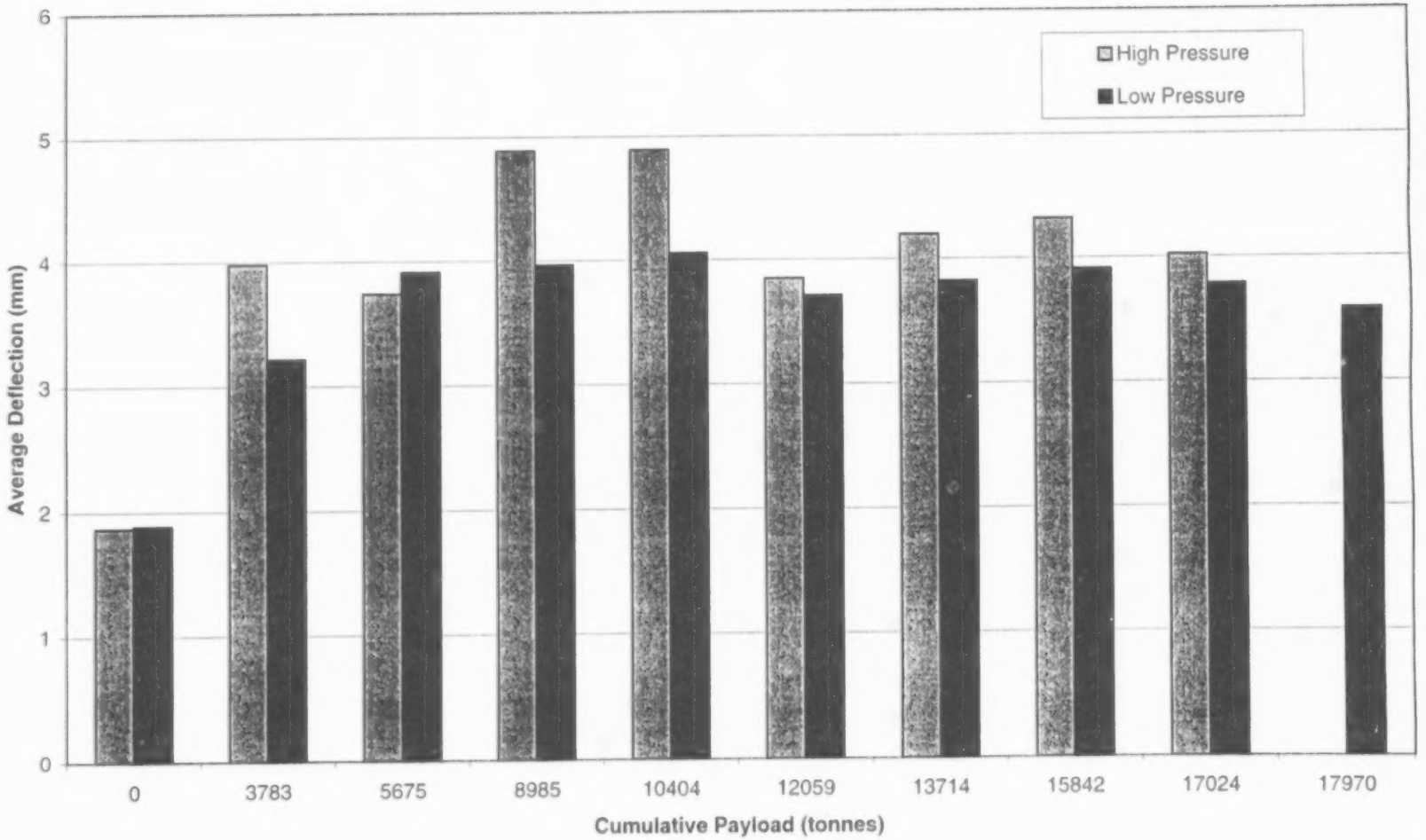


Figure 1-14

Equal Payloads Gravel Test Road
Test Road 202
Cumulative Payload versus Length of Test Lane Failure (%)

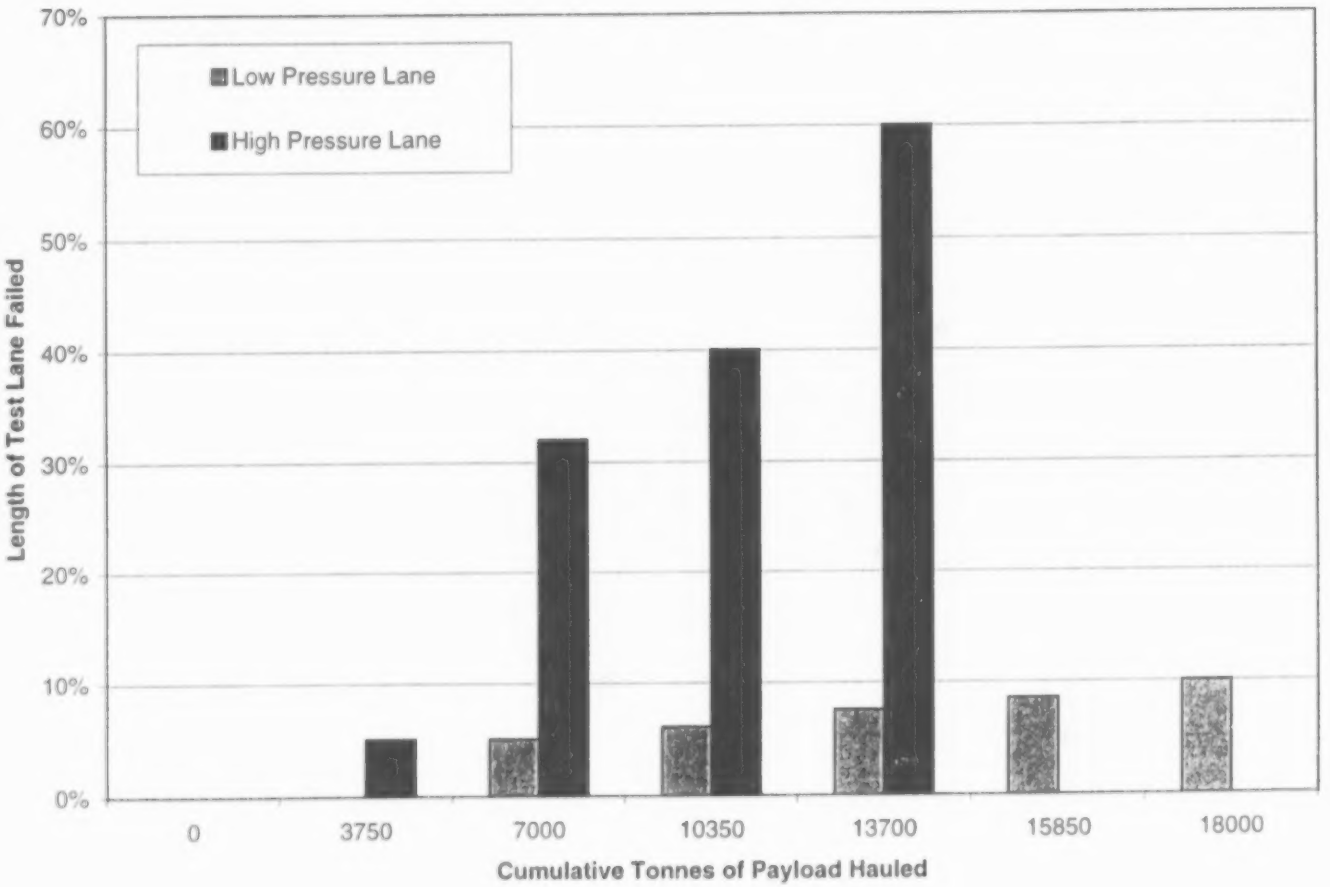


Figure 1-15

Equal Payloads TMS Test Road
Test Road 202
Cumulative Payload versus Length of Test Lane Failure (%)

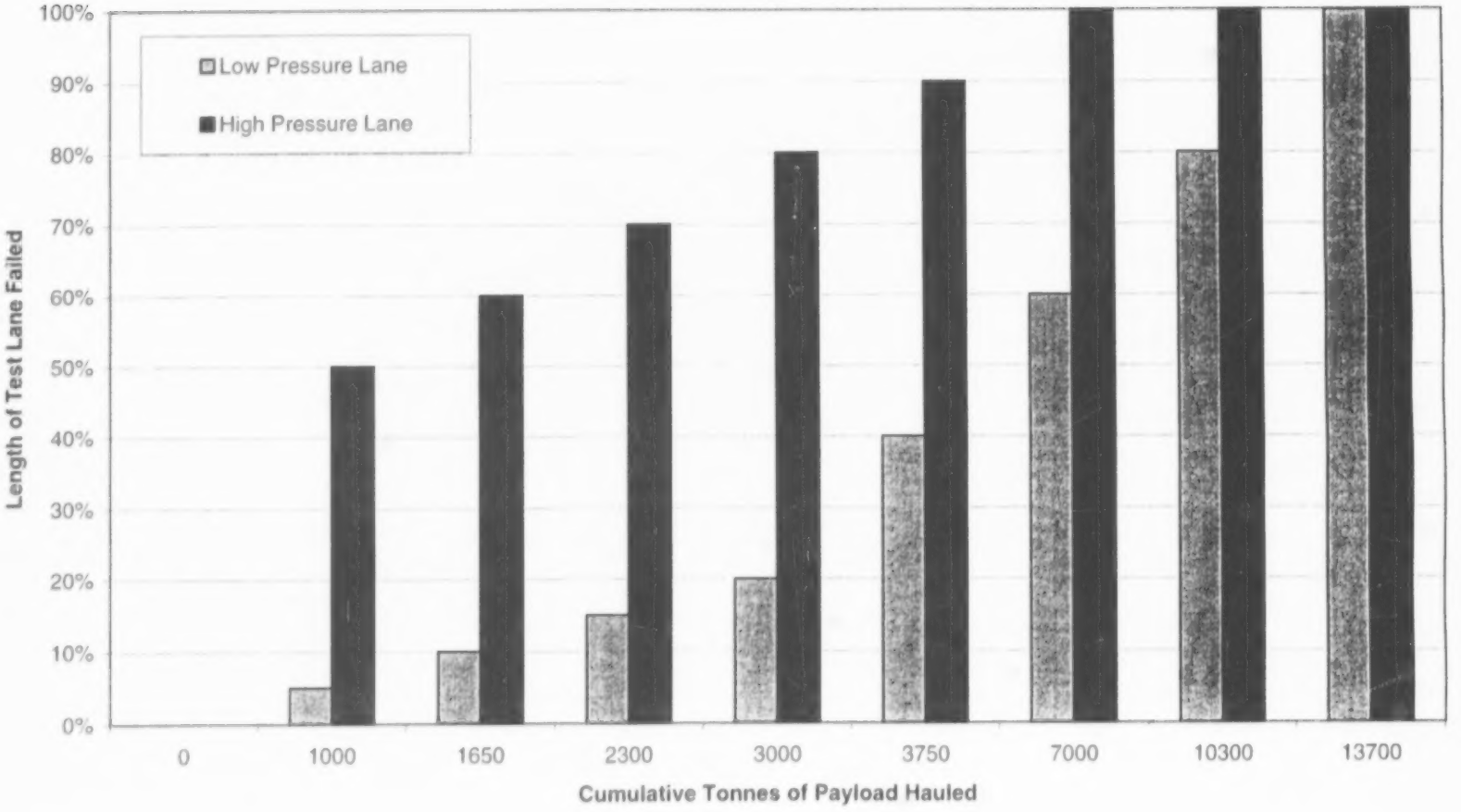


Figure 3-1

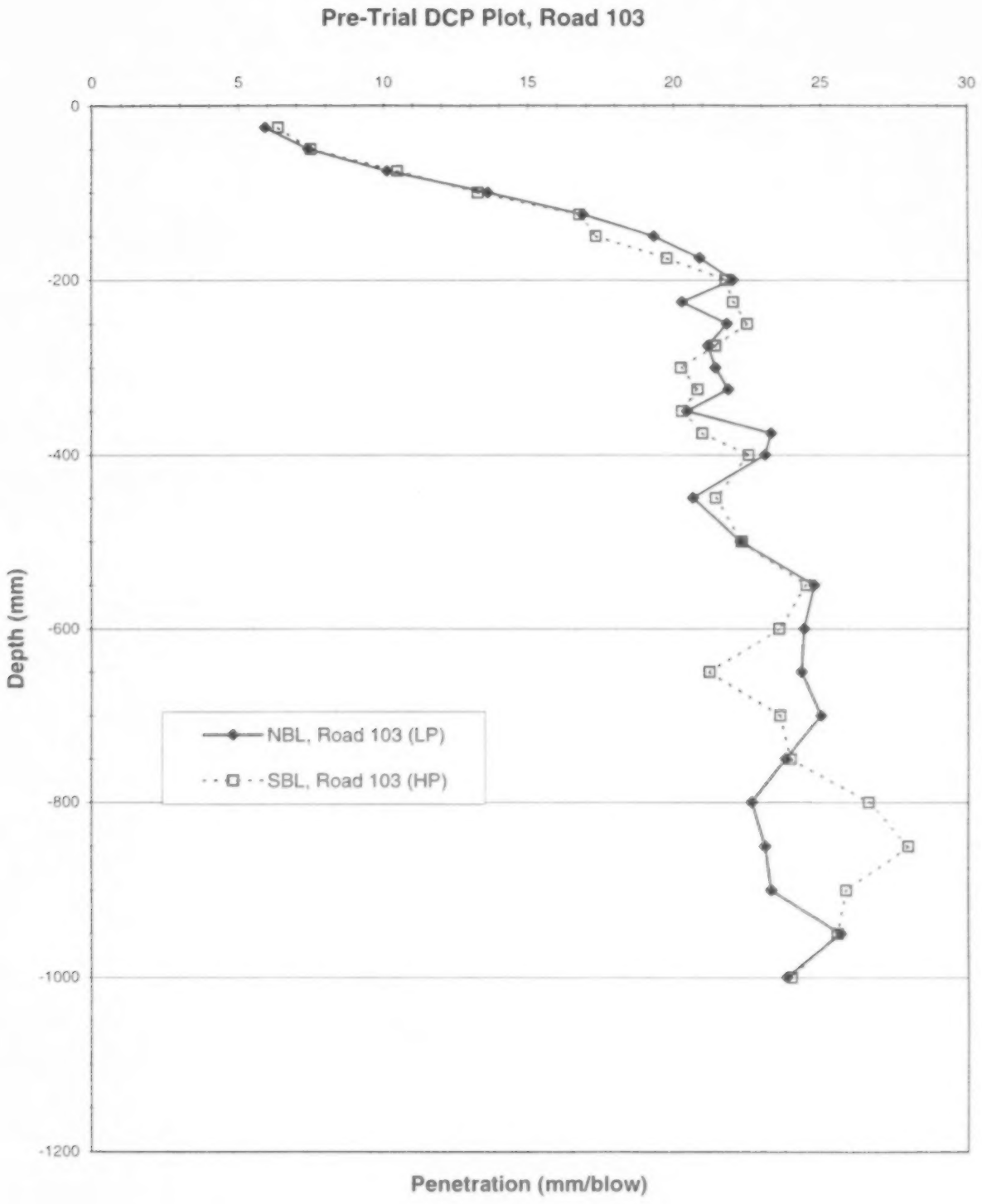

Pre-Trial DCP Plot, Road 103
0
5
10
15
20
25
30
0
-200
-400
-600
-800
-1000
-1200
Depth (mm)
NBL, Road 103 (LP)
SBL, Road 103 (HP)
Penetration (mm/blow)

Figure 3-2

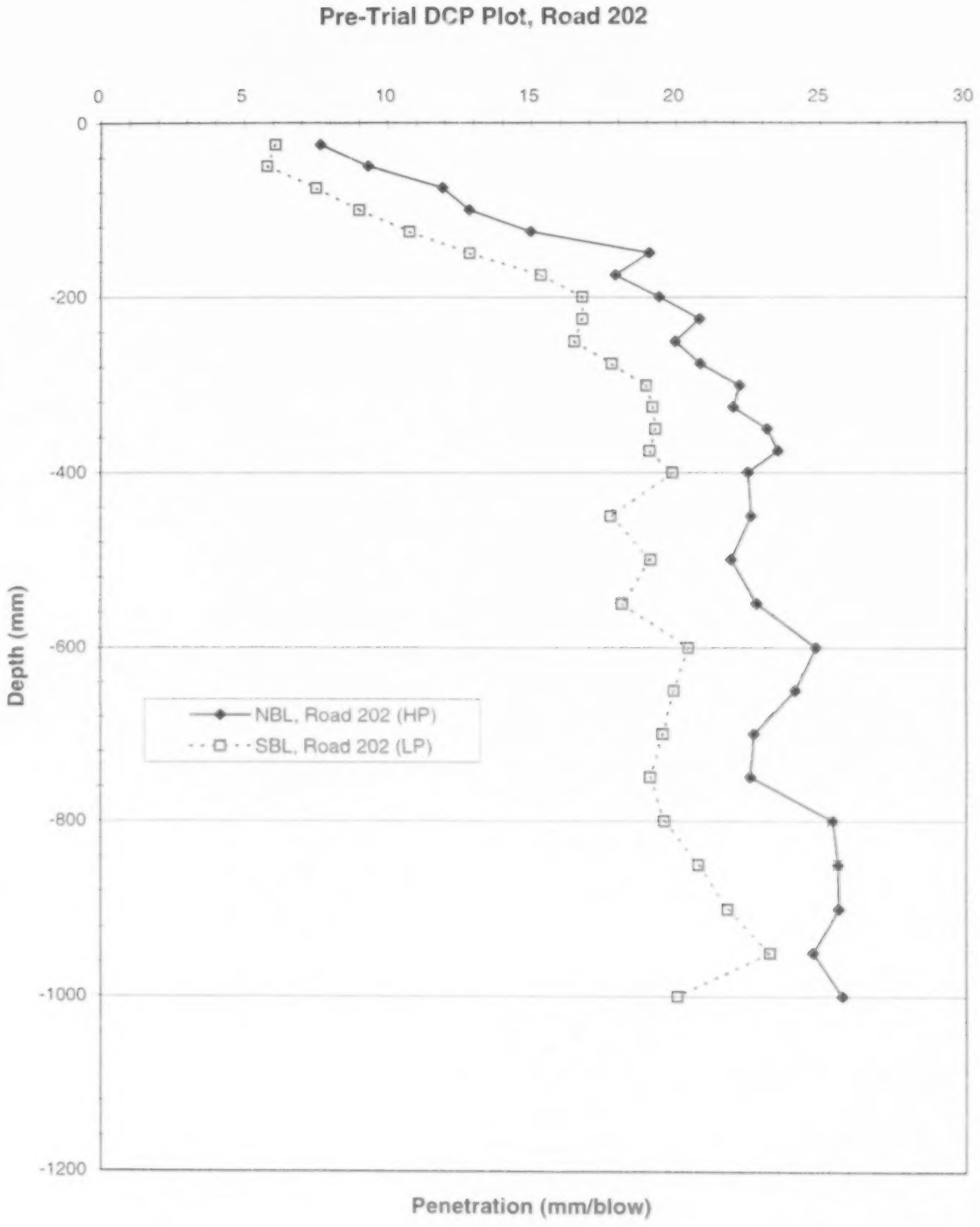

Pre-Trial DCP Plot, Road 202
0
5
10
15
20
25
30
0
-200
-400
-600
-800
-1000
-1200
Depth (mm)
NBL, Road 202 (HP)
SBL, Road 202 (LP)
Penetration (mm/blow)

Figure 3-3

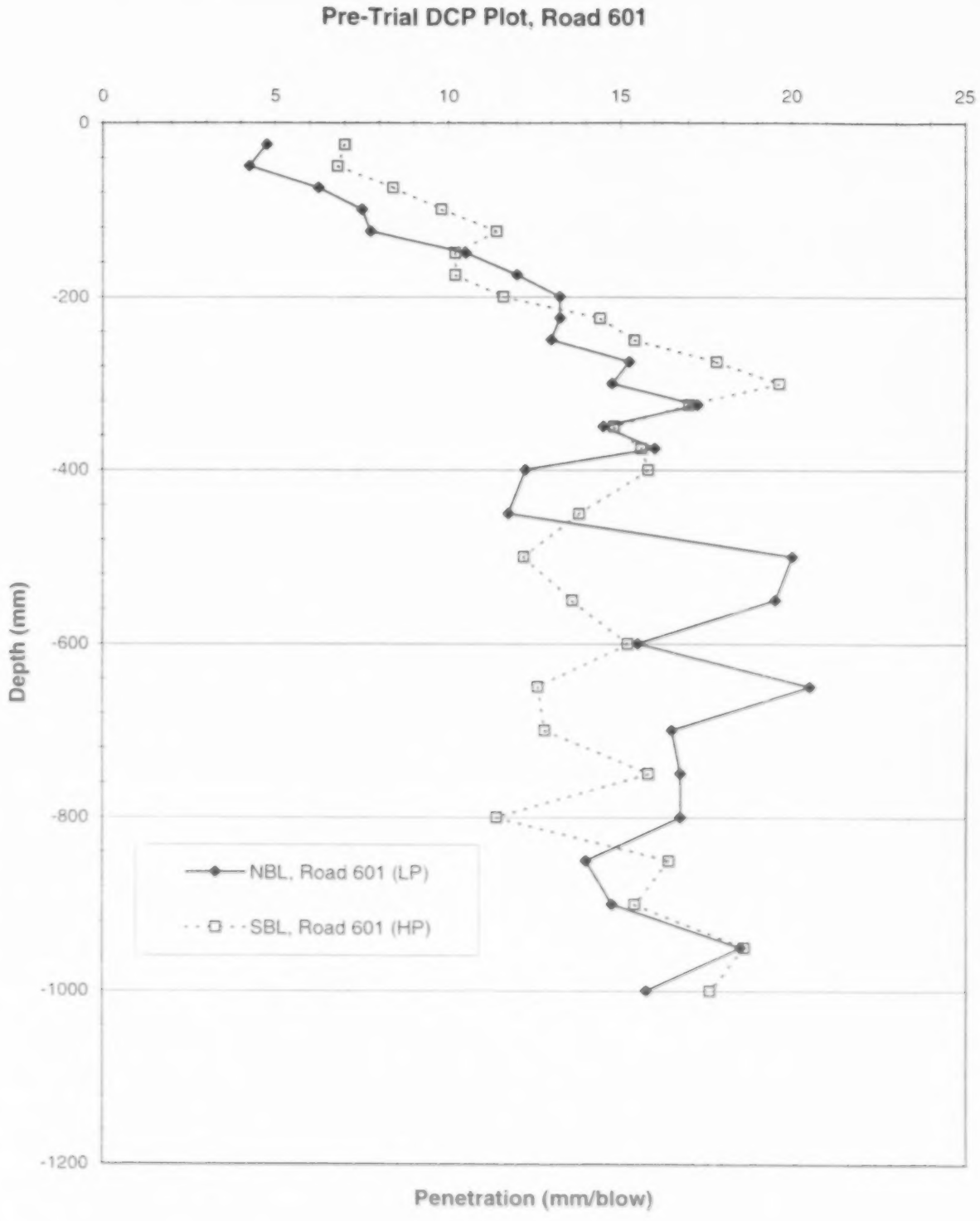

Pre-Trial DCP Plot, Road 601
0
5
10
15
20
25
0
-200
-400
-600
-800
-1000
-1200
Depth (mm)
NBL, Road 601 (LP)
SBL, Road 601 (HP)
Penetration (mm/blow)

Figure 4-1
Average DCP Profiles, Test Road 103, 07/12/00

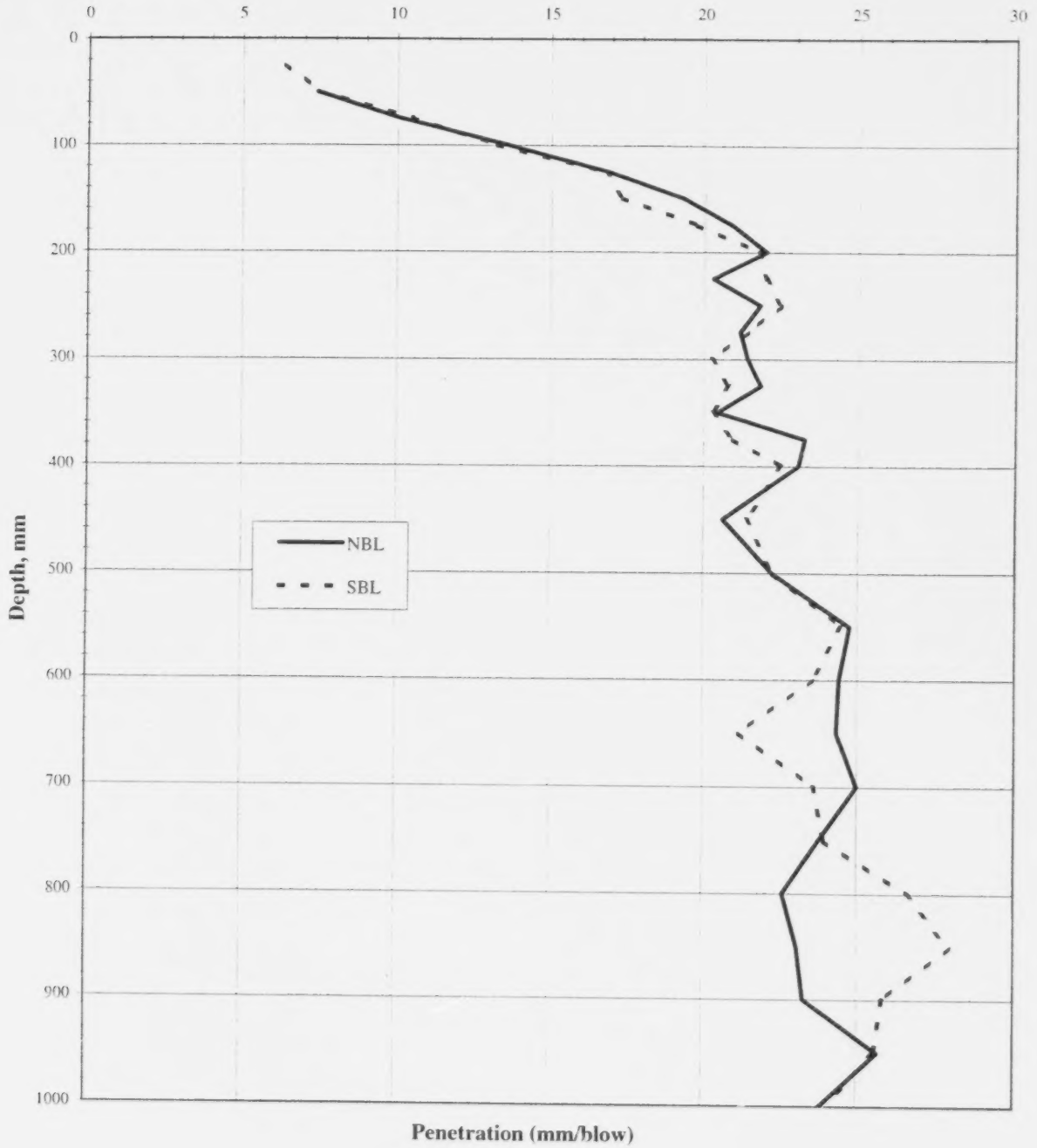


Figure 4-2
Average DCP Profiles, Test Road 103 (S of Road 105), 07/12/00

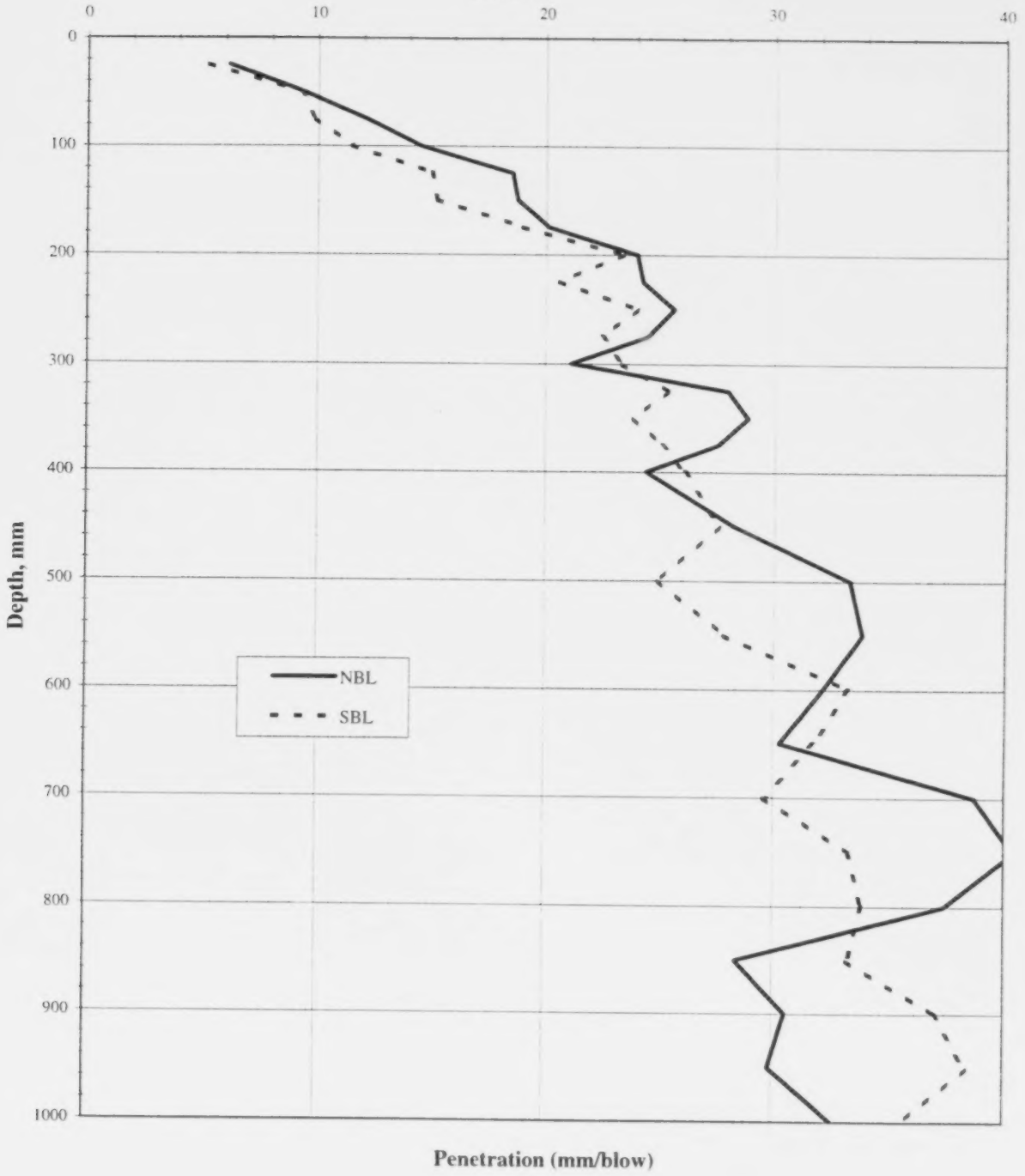


Figure 4-3
Average DCP Profiles - Post Trial, Road 103, 08/02/00

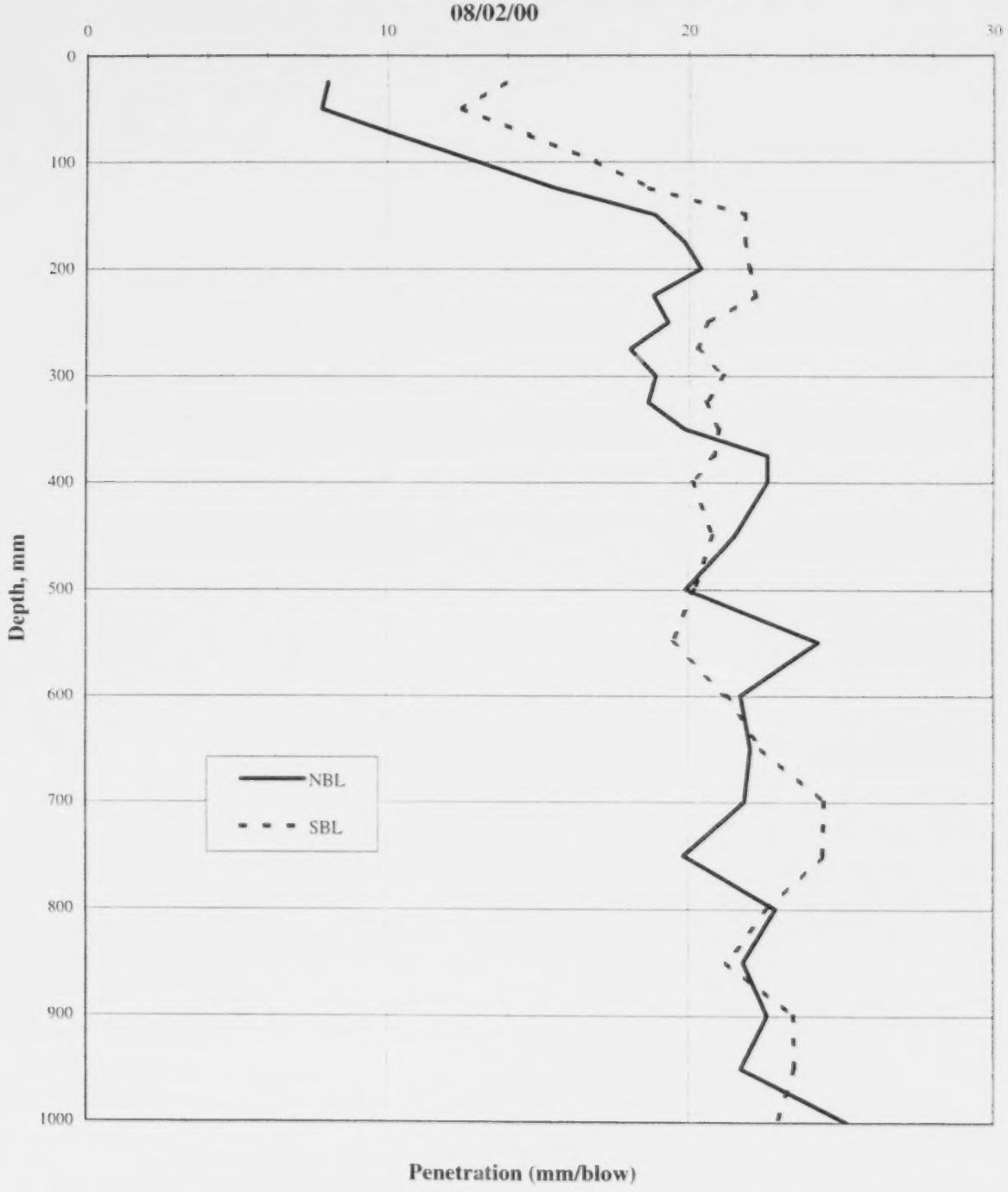


Figure 4-4
Average DCP Profiles - Post Trial, Test Road 103,
S of Road 105, 08/02/00

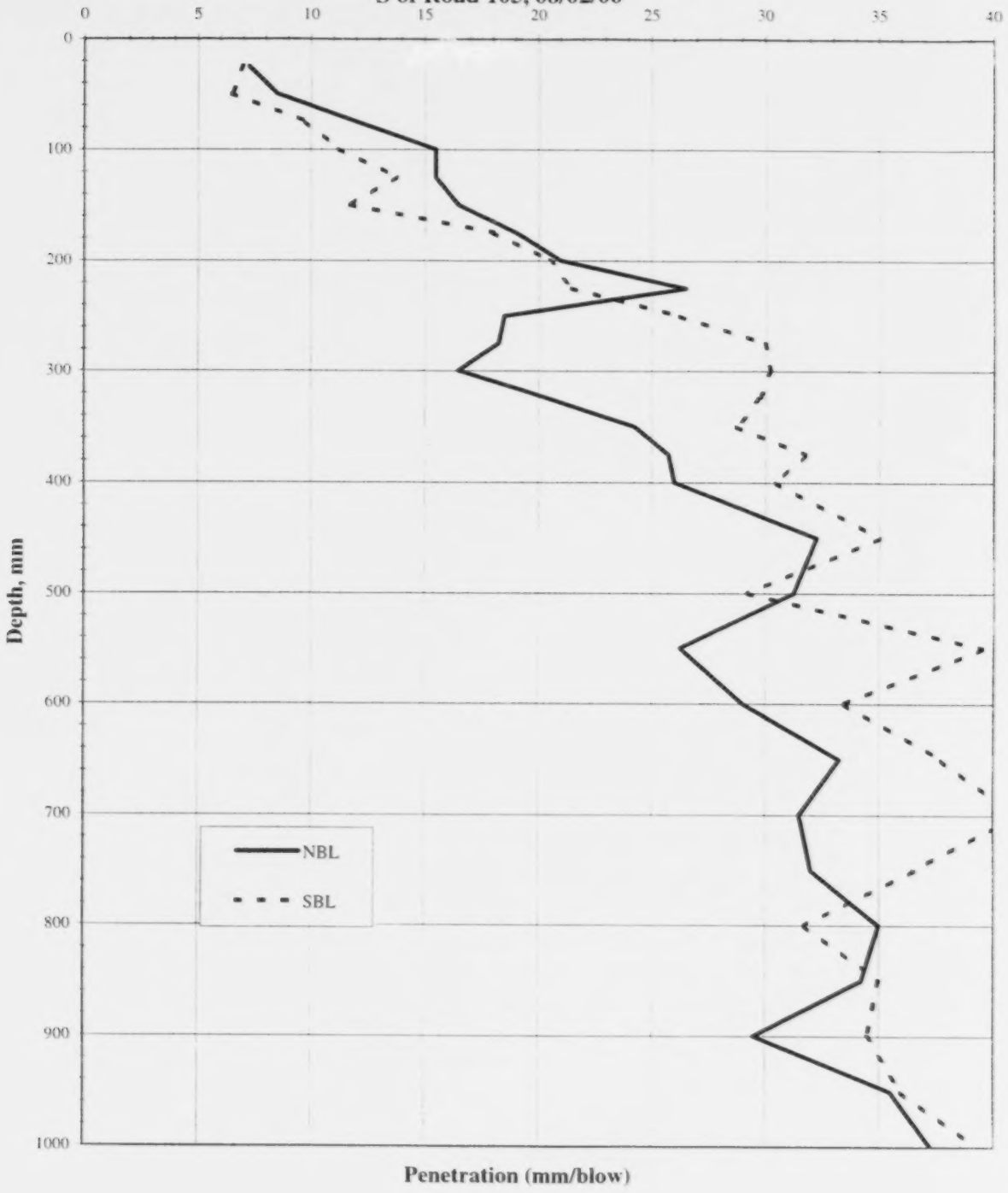


Figure 4-5
Average DCP Profiles, Test Road 103, NBL

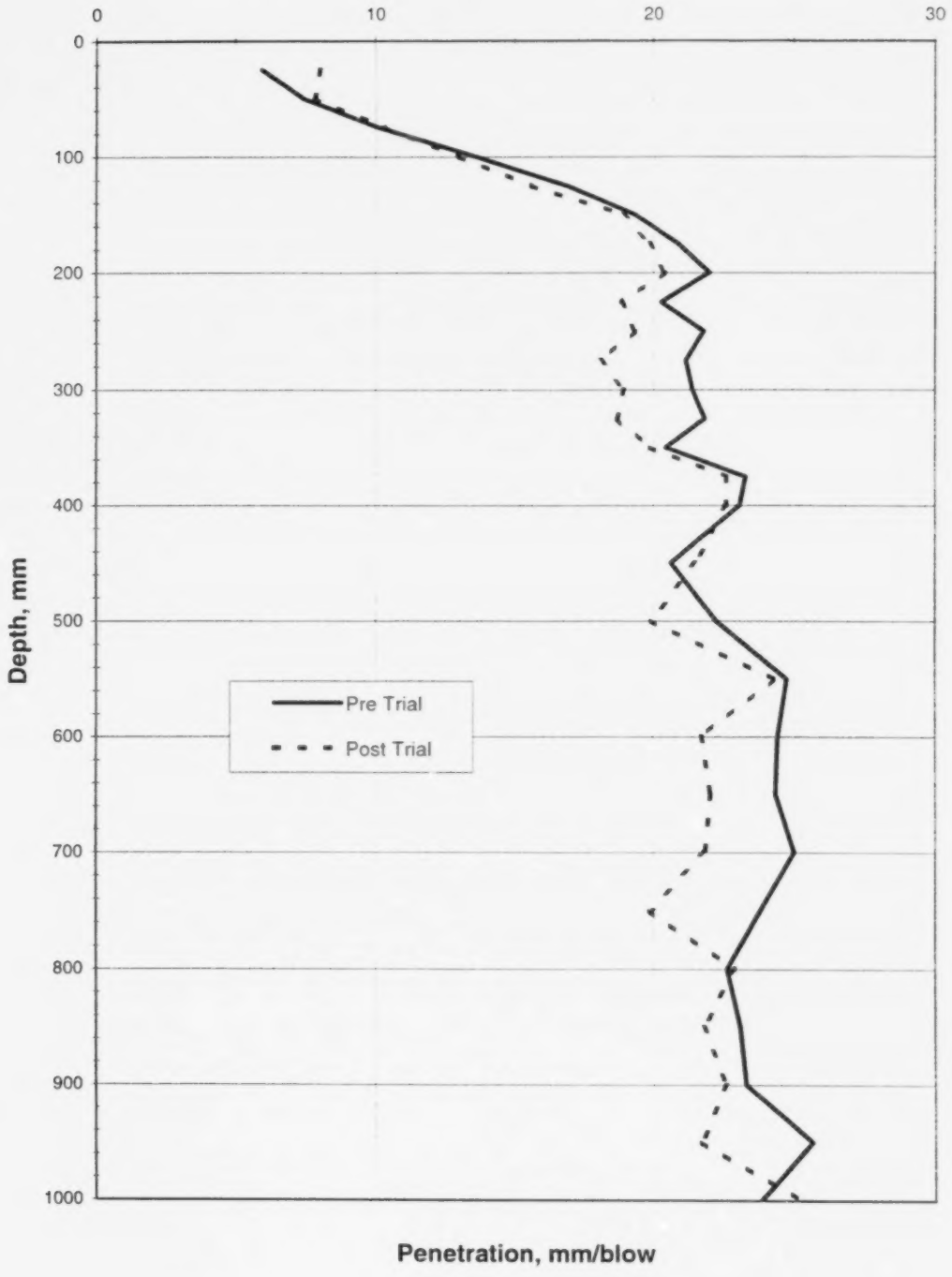


Figure 4-6
Average DCP Profiles, Test Road 103, SBL

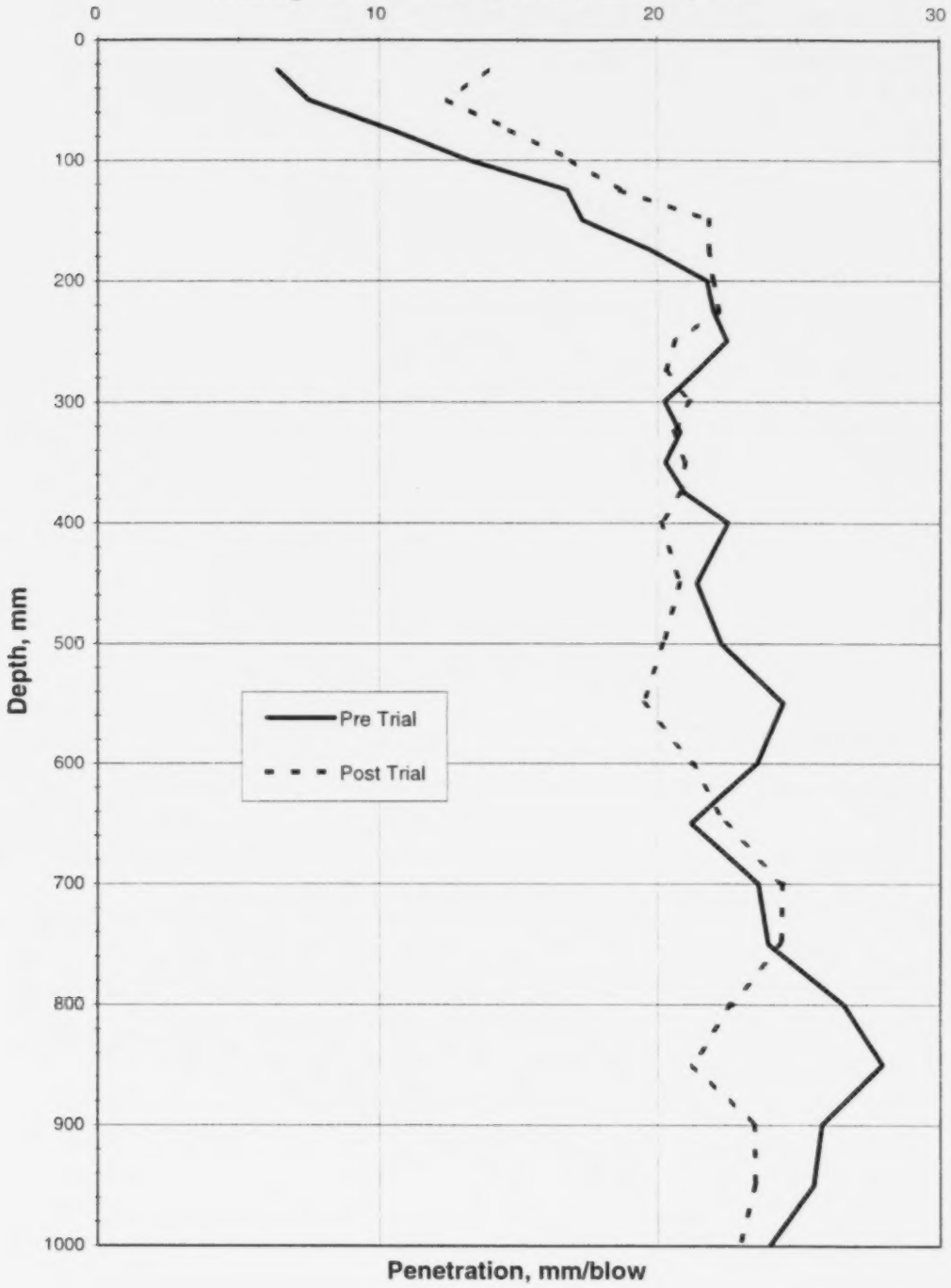


Figure 4-7
Differences in mm/blow, NBL

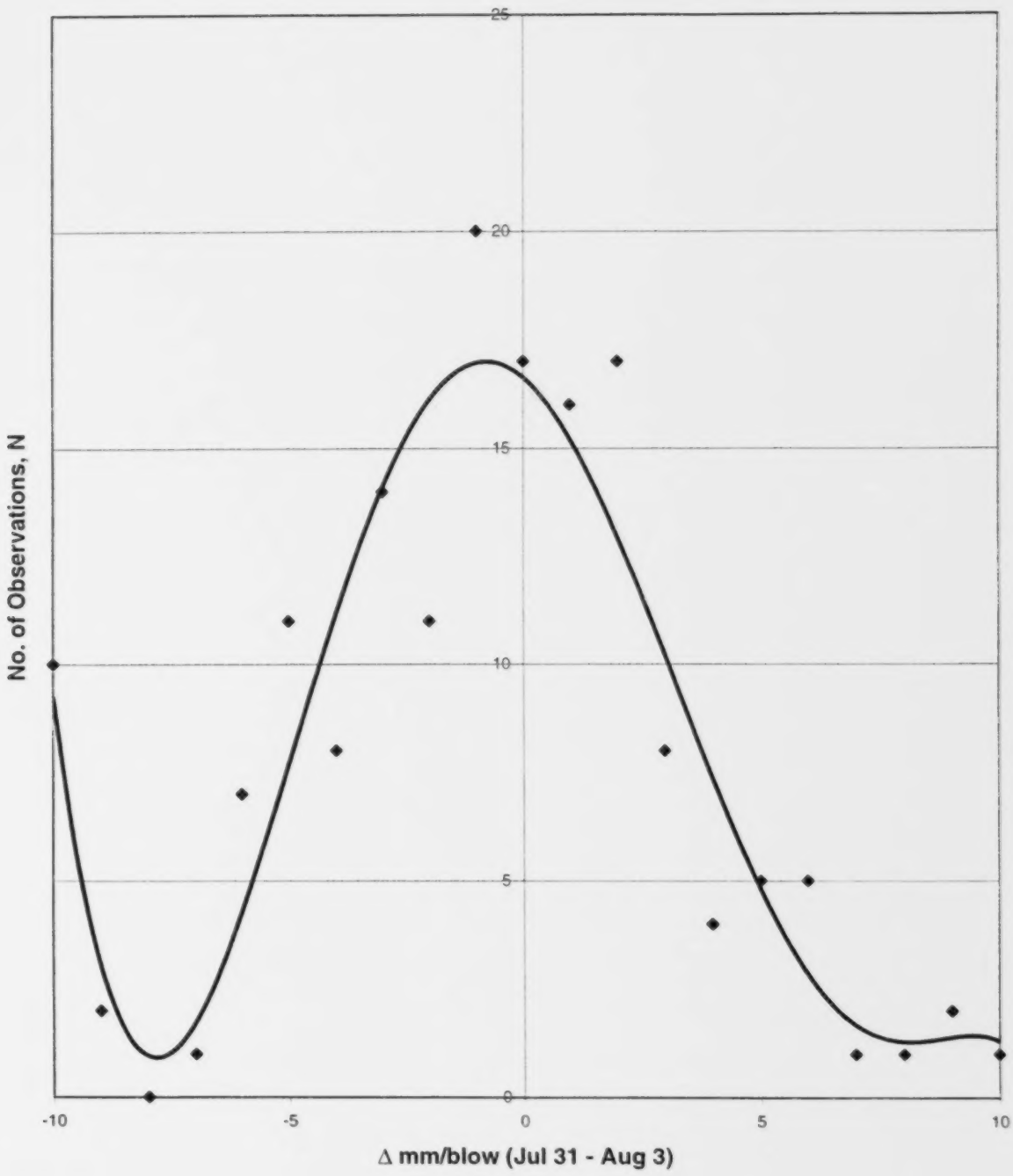


Figure 4-8
Differences in mm/blow, SBL

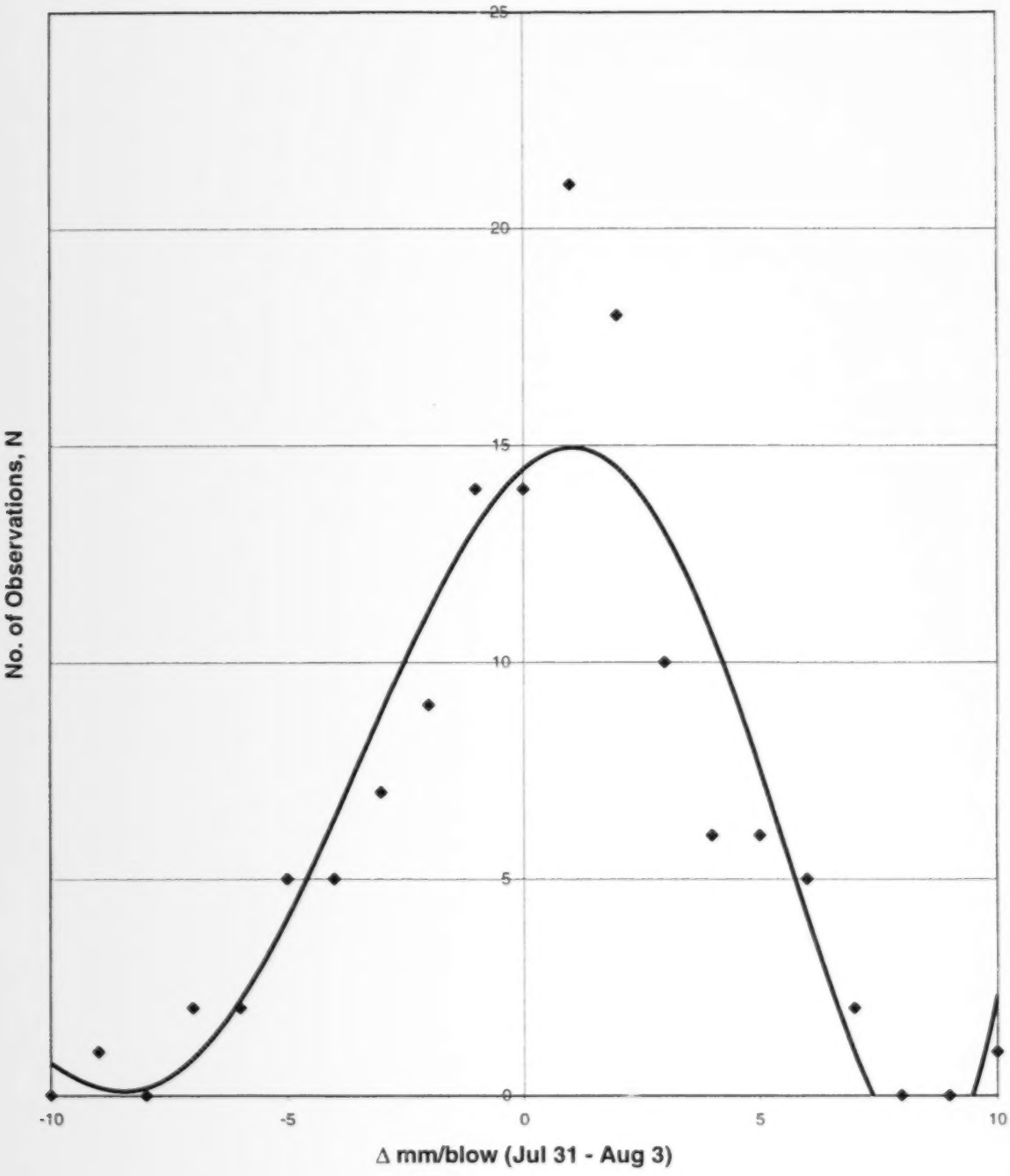


Figure 4-9
Average DCP Profiles - Pre-Trial, Test Road 202

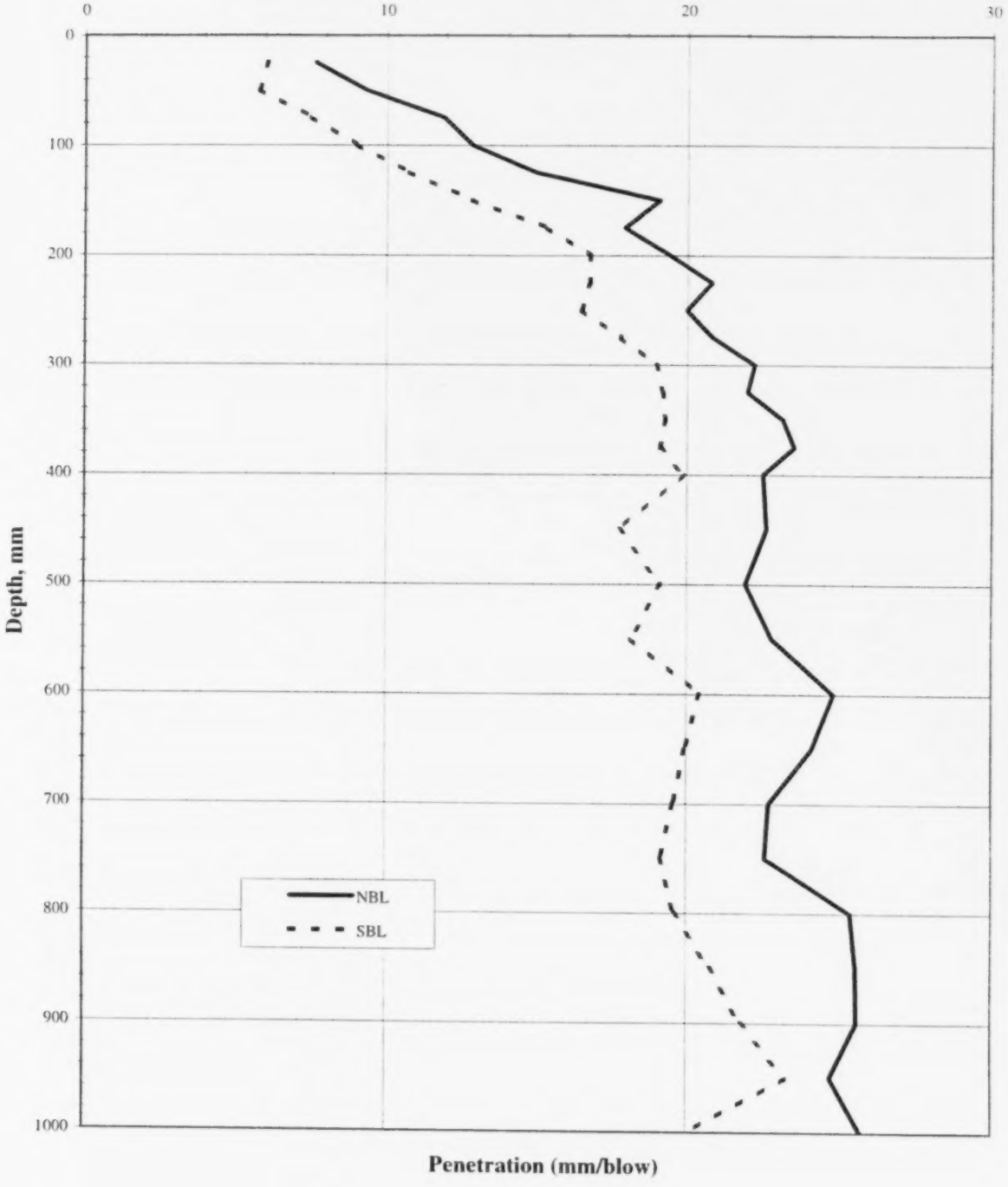


Figure 4-10
Average DCP Profiles - Pre-Trial, Test Road 202 (S of Road 206)

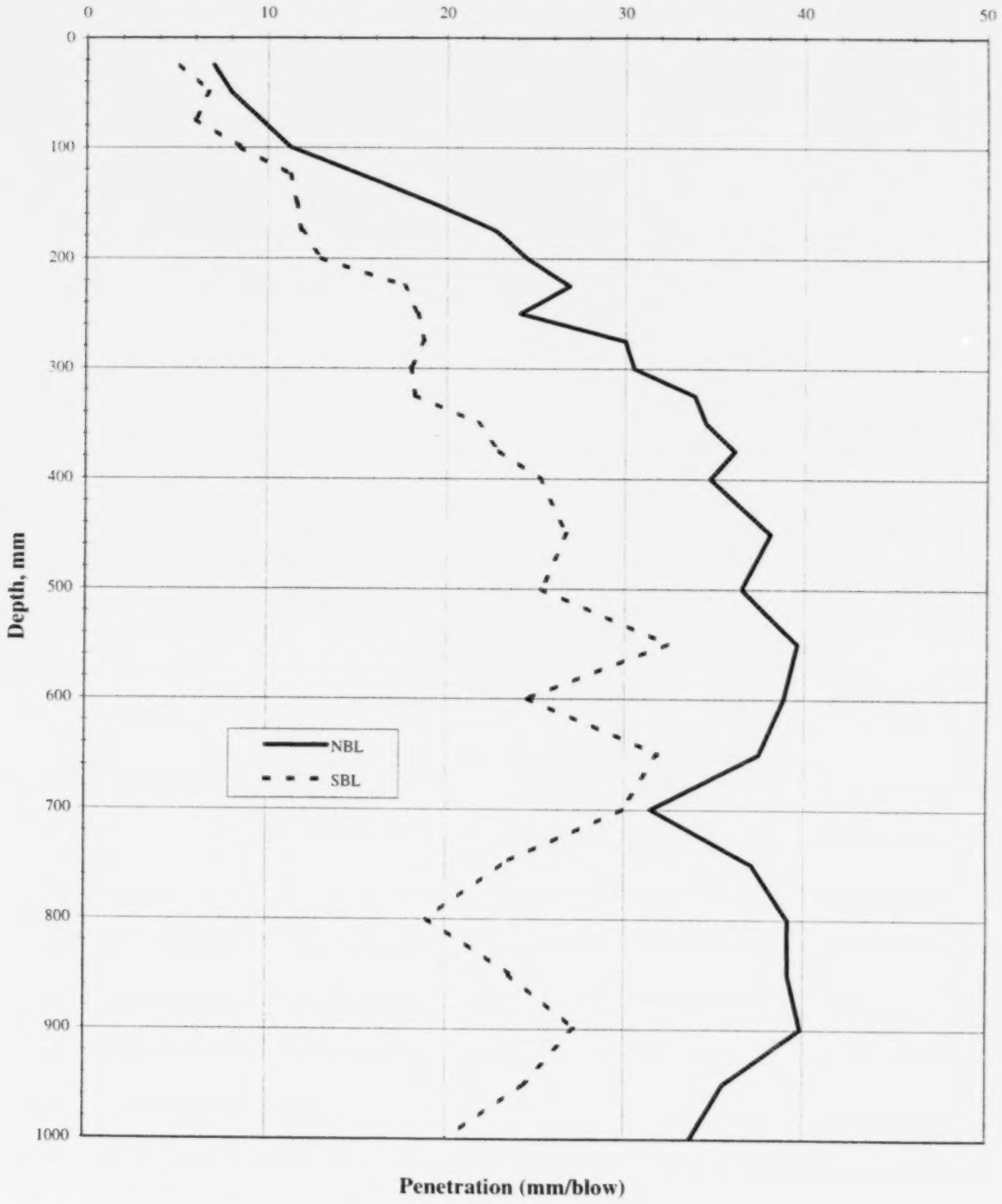


Figure 4-11
Average DCP Profiles - Post Trial, Test Road 202

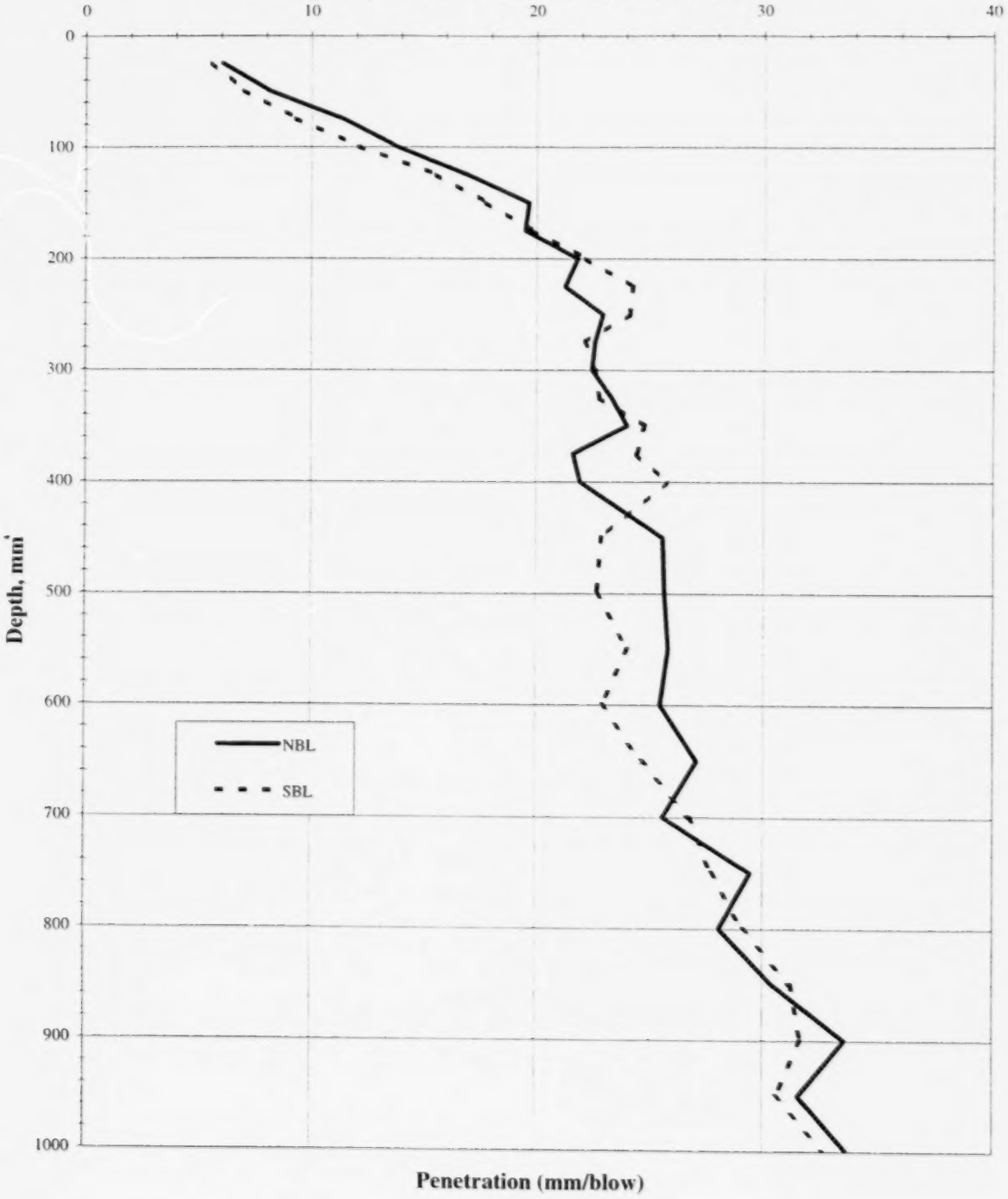


Figure 4-12
Average DCP Profiles - Post Trial, Test Road 202
(S of Road 206)

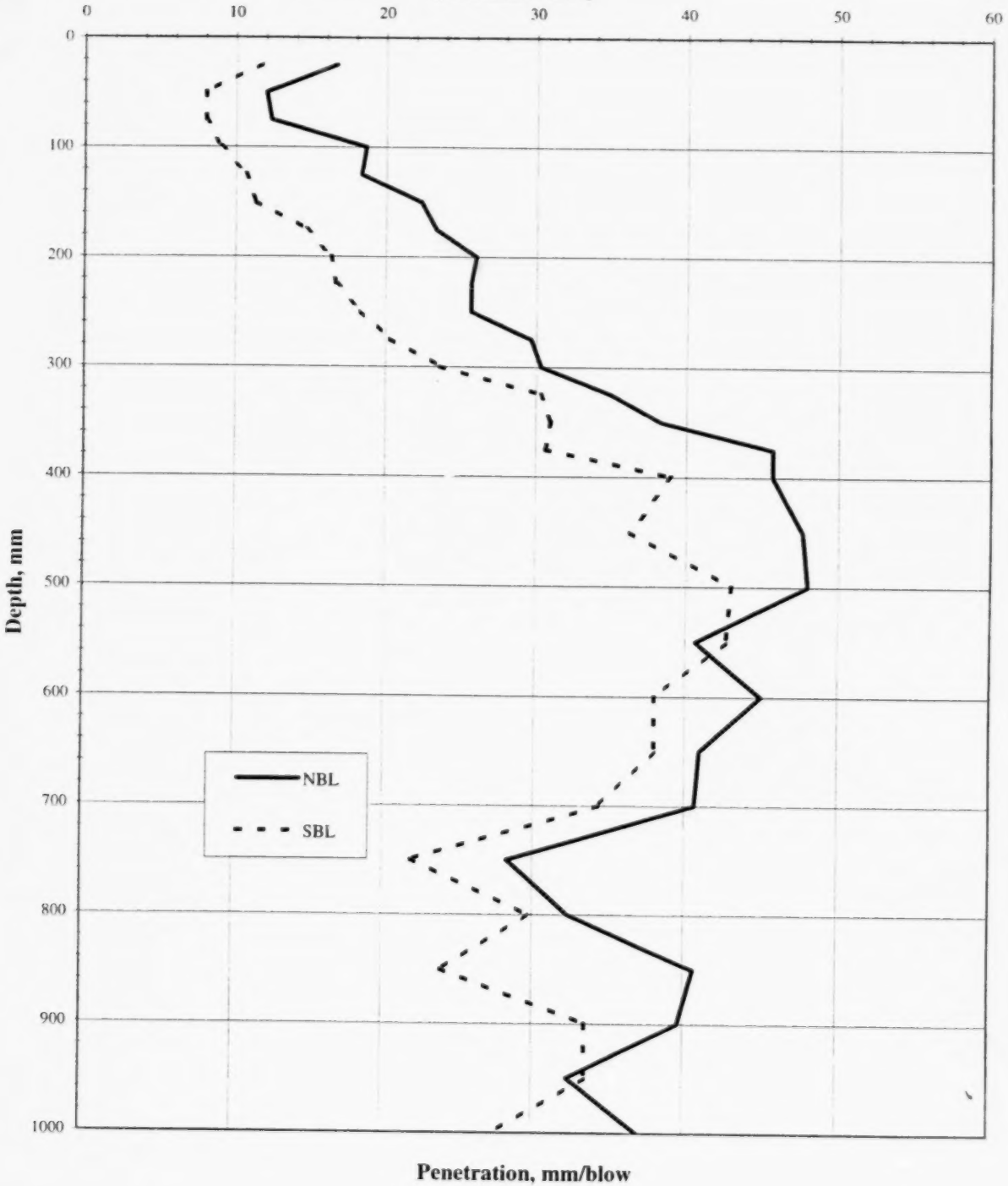
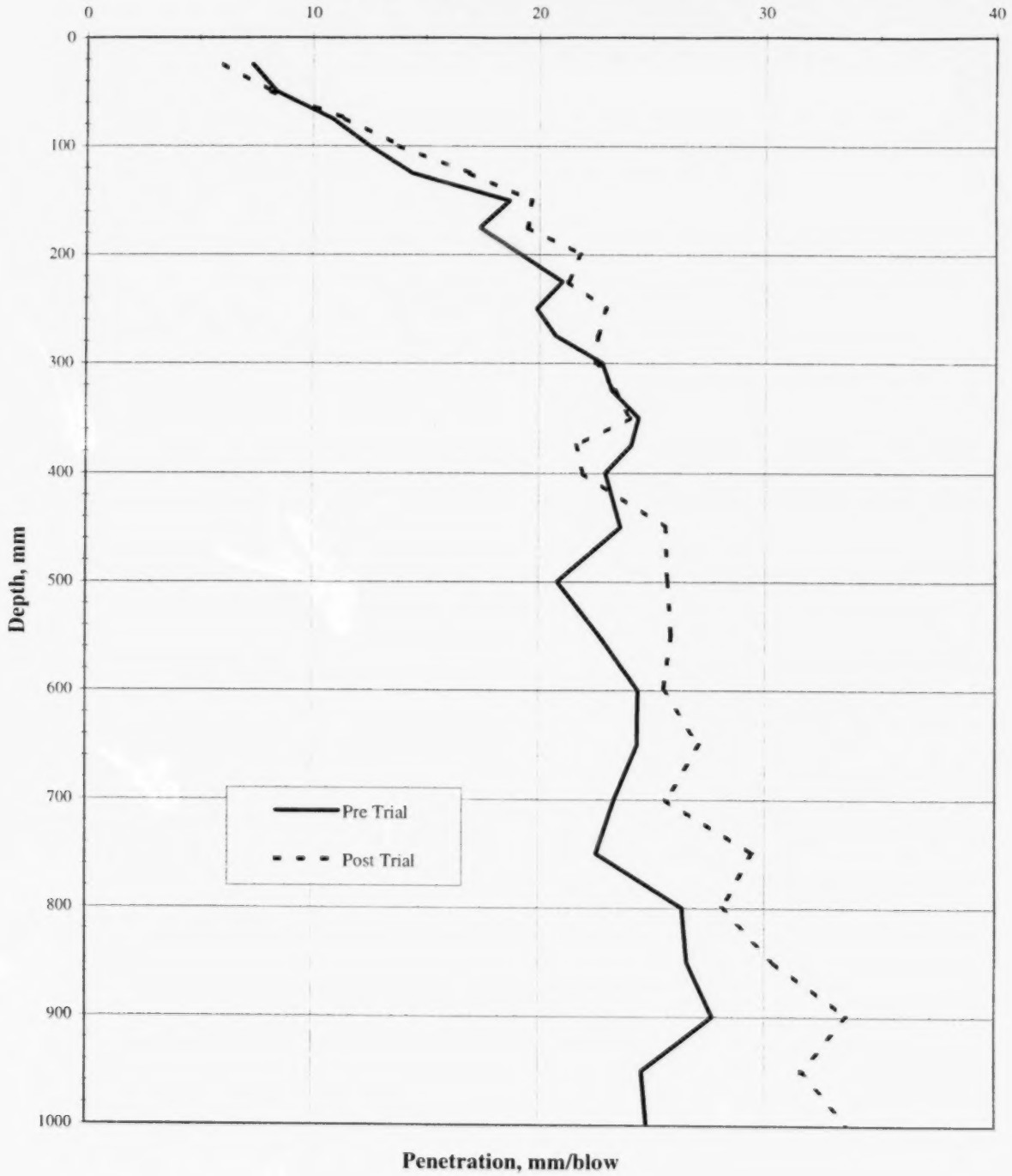


Figure 4-13
Average DCP Profiles, Test Road 202, NBL



DCP202INI

Figure 4-14
Average DCP Profiles, Test Road 202, SBL

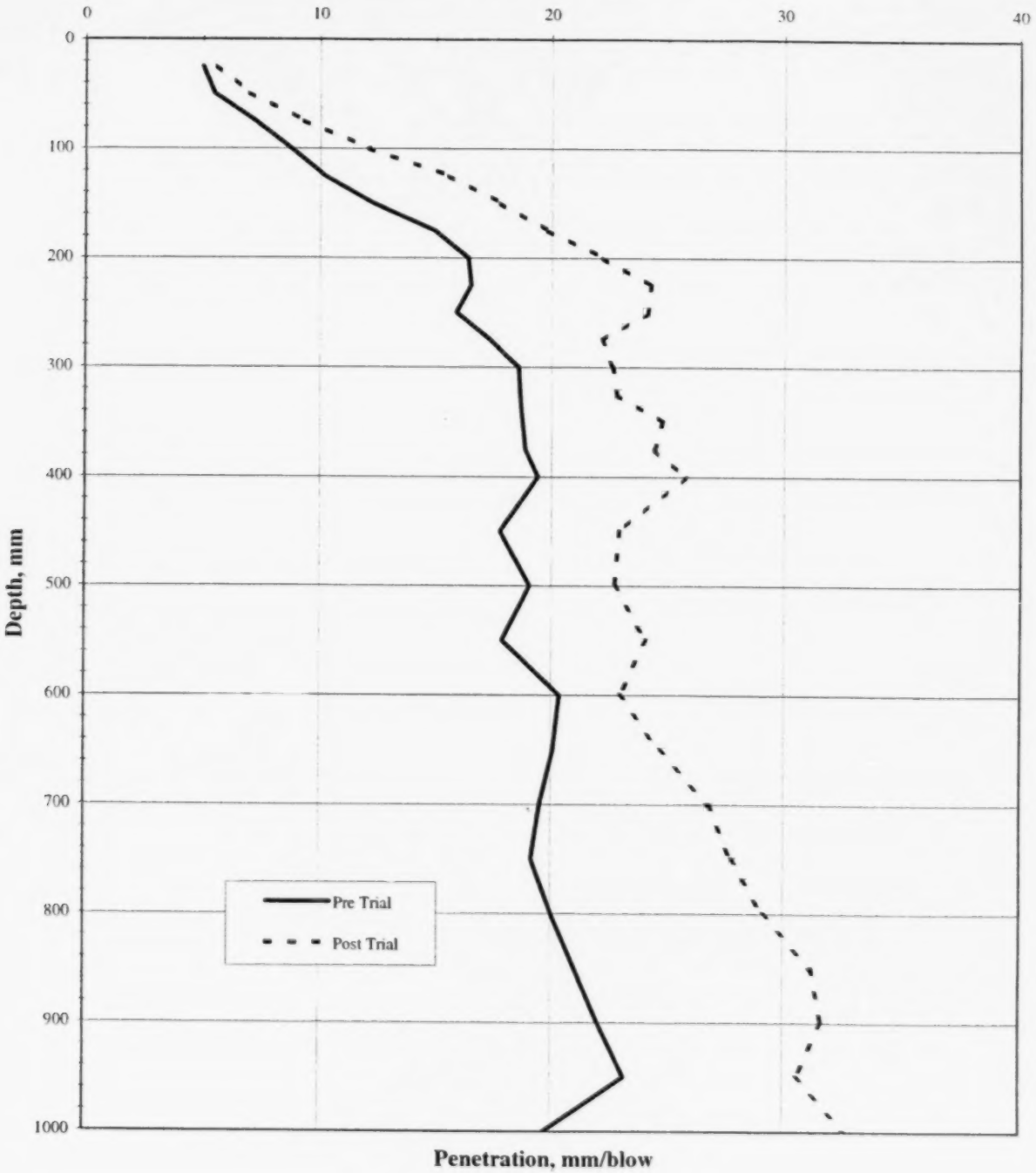


Figure 4-15
DCP Profiles, Grid 601 Test Loop

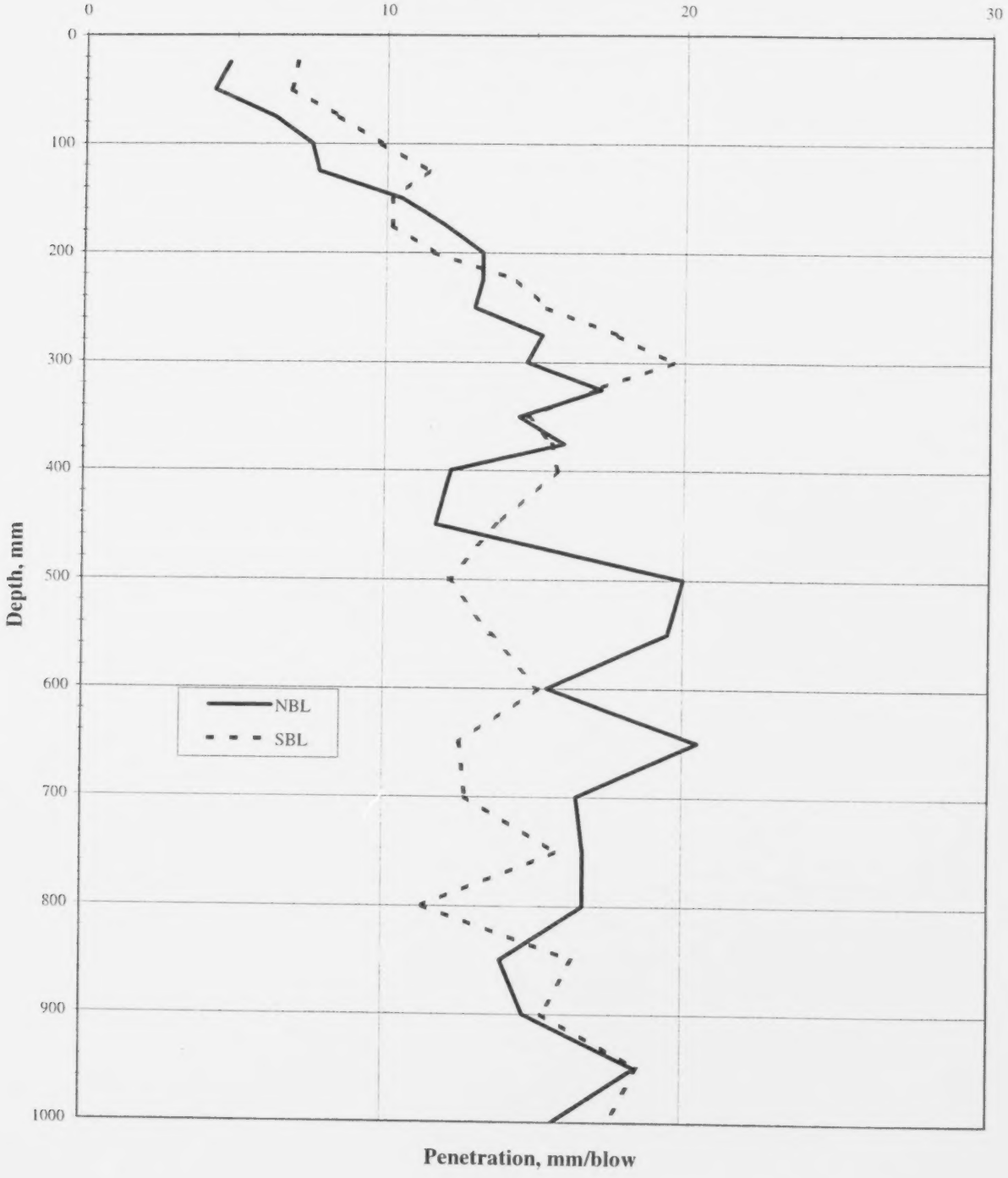


Figure 4-16
DCP Profiles, Grid 601, South of Test Loops

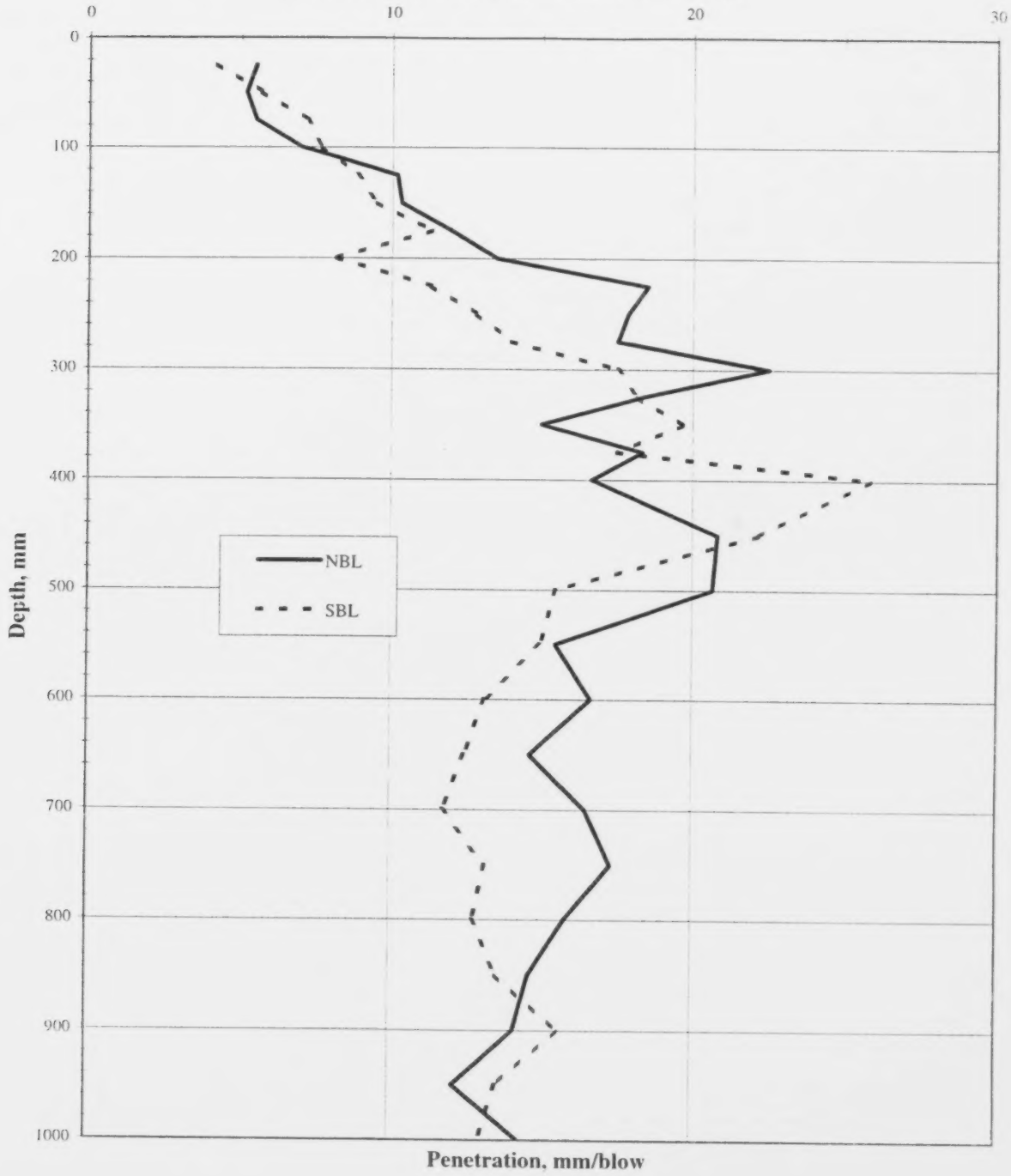


Figure 4-17
Average DCP Profiles, Grid Road 601 and Test Road 103

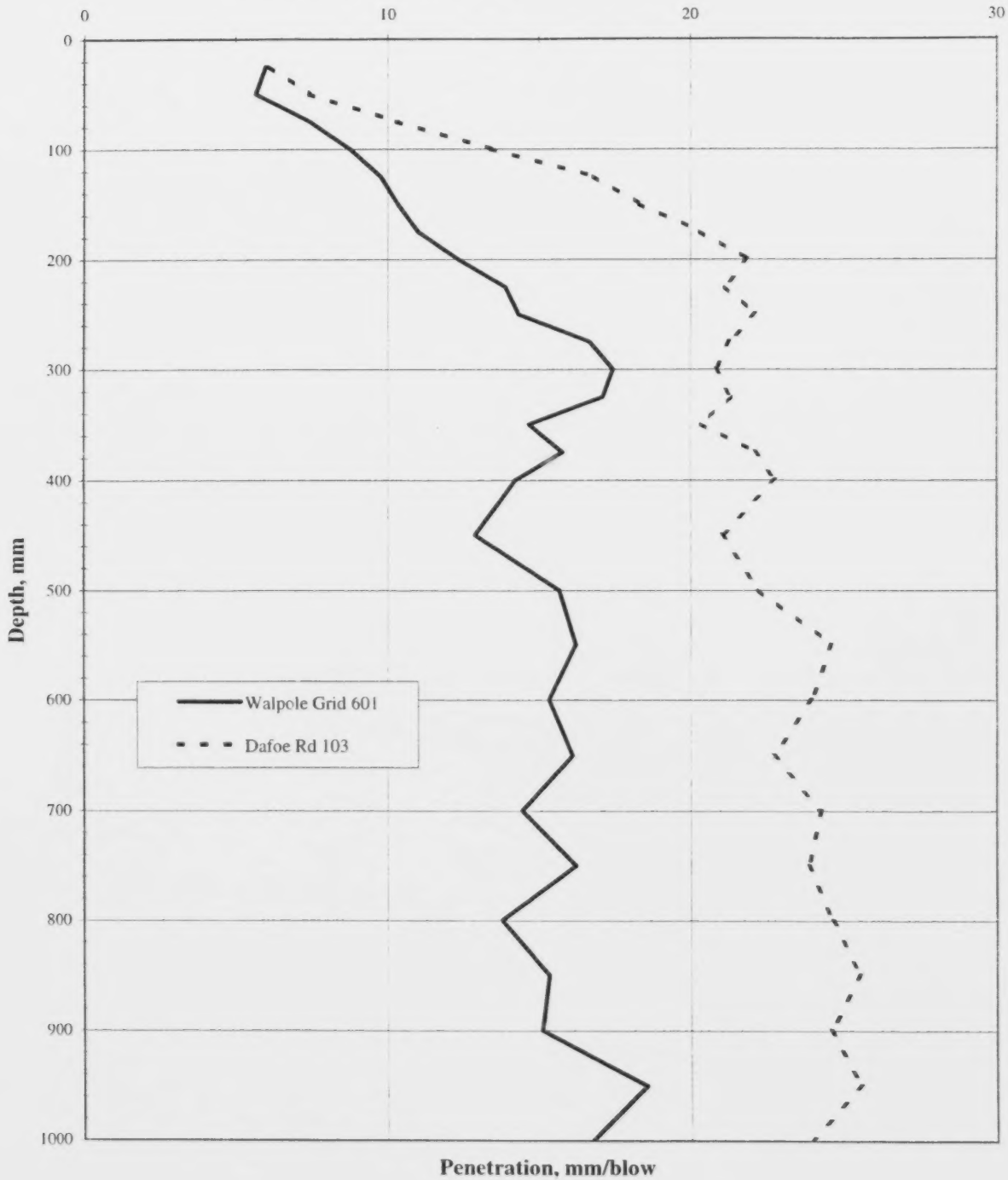
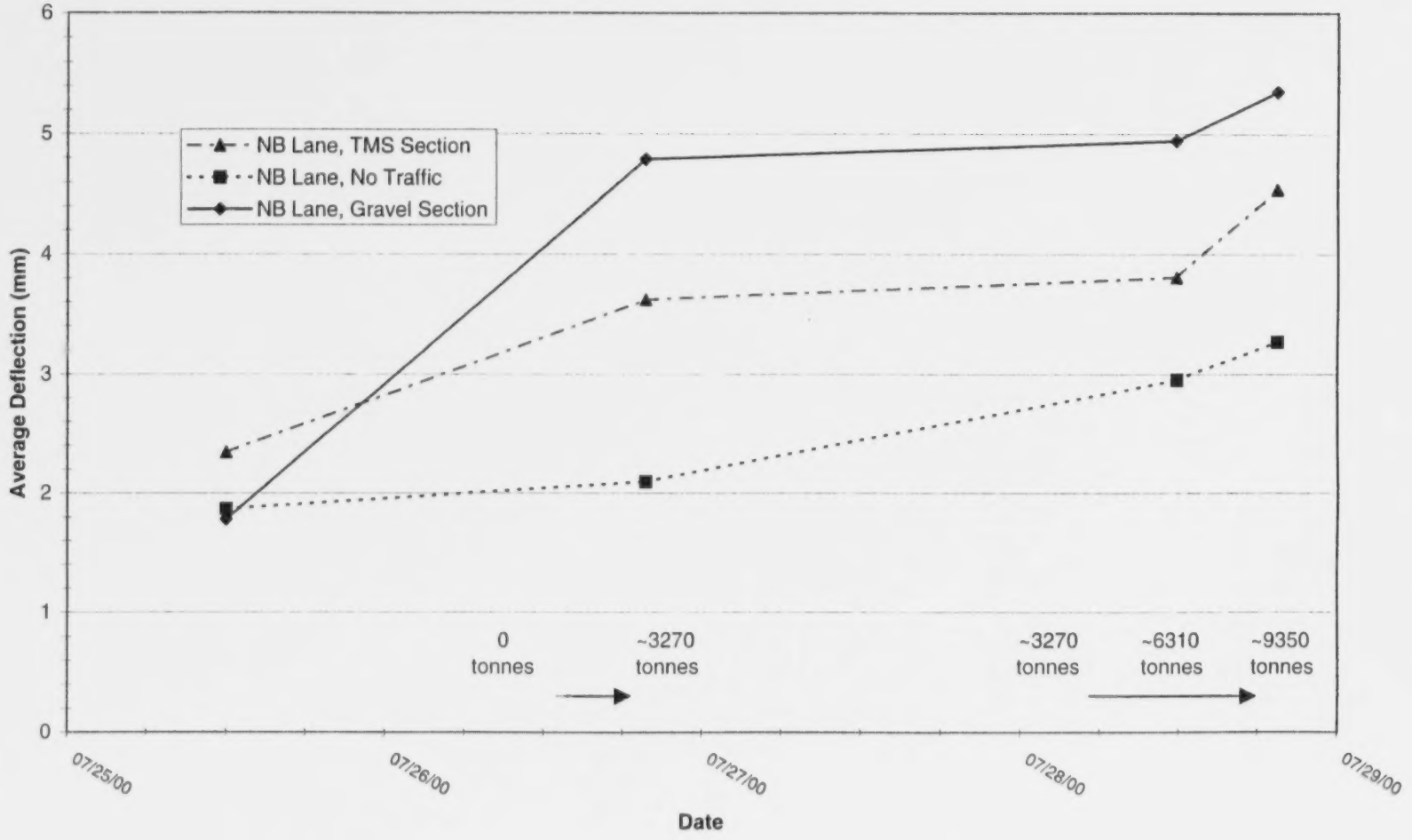


Figure 4-18
Average Daily Deflections - Northbound Lane, Road 103



ROAD103AVERAGES

Figure 4-19
Comparison Deflections - Road 103
Northbound (High Tire Pressure) Lane

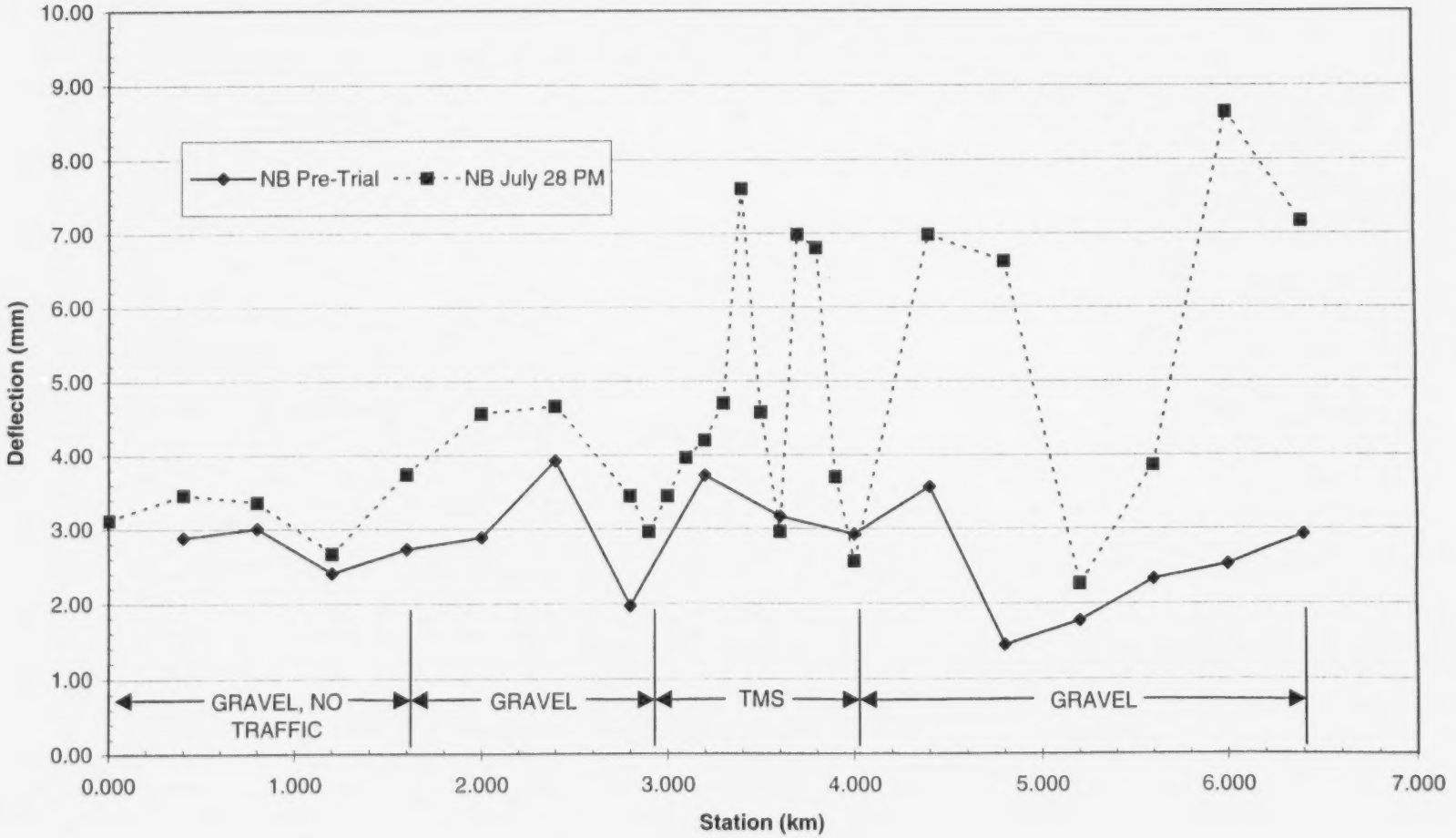
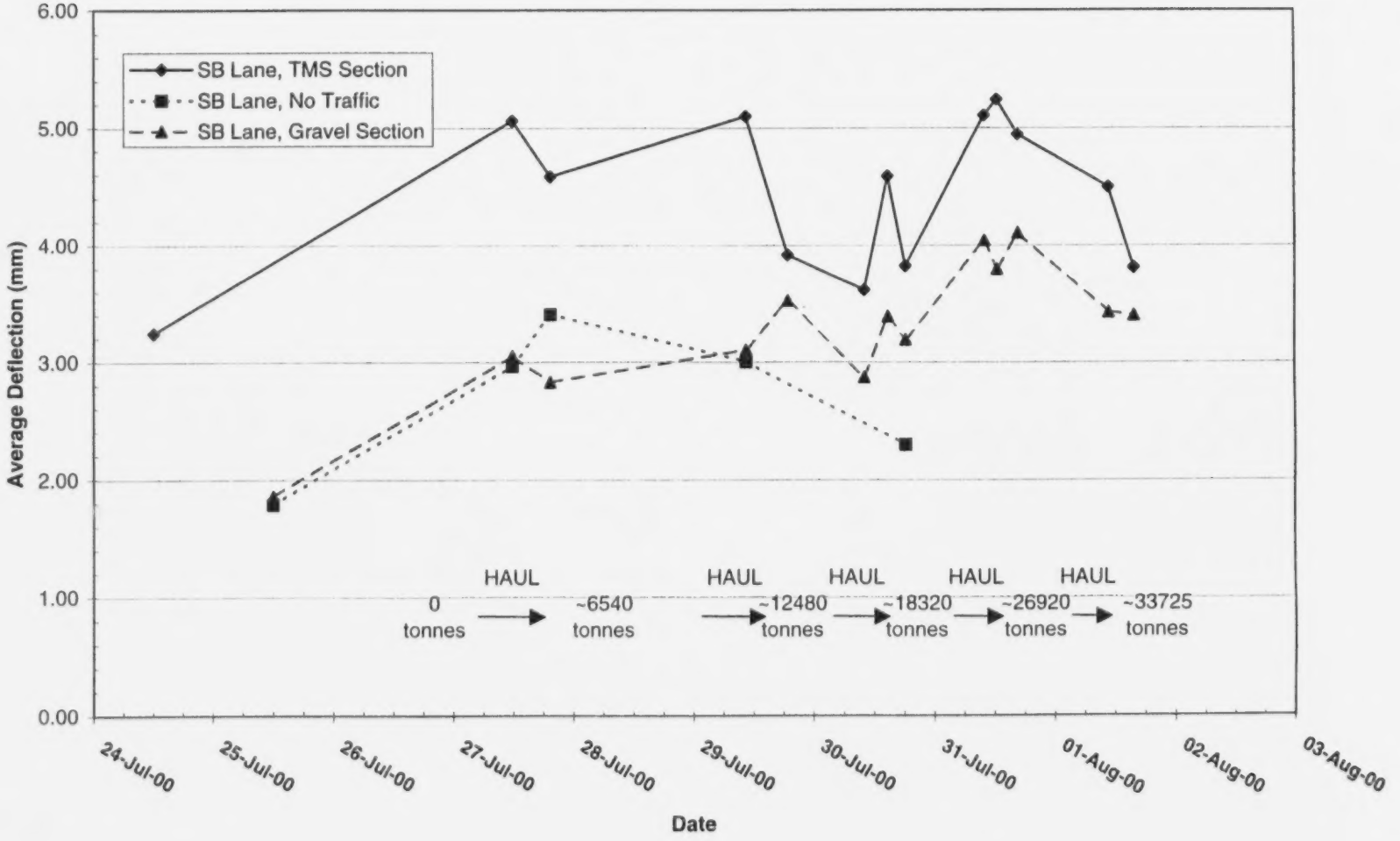
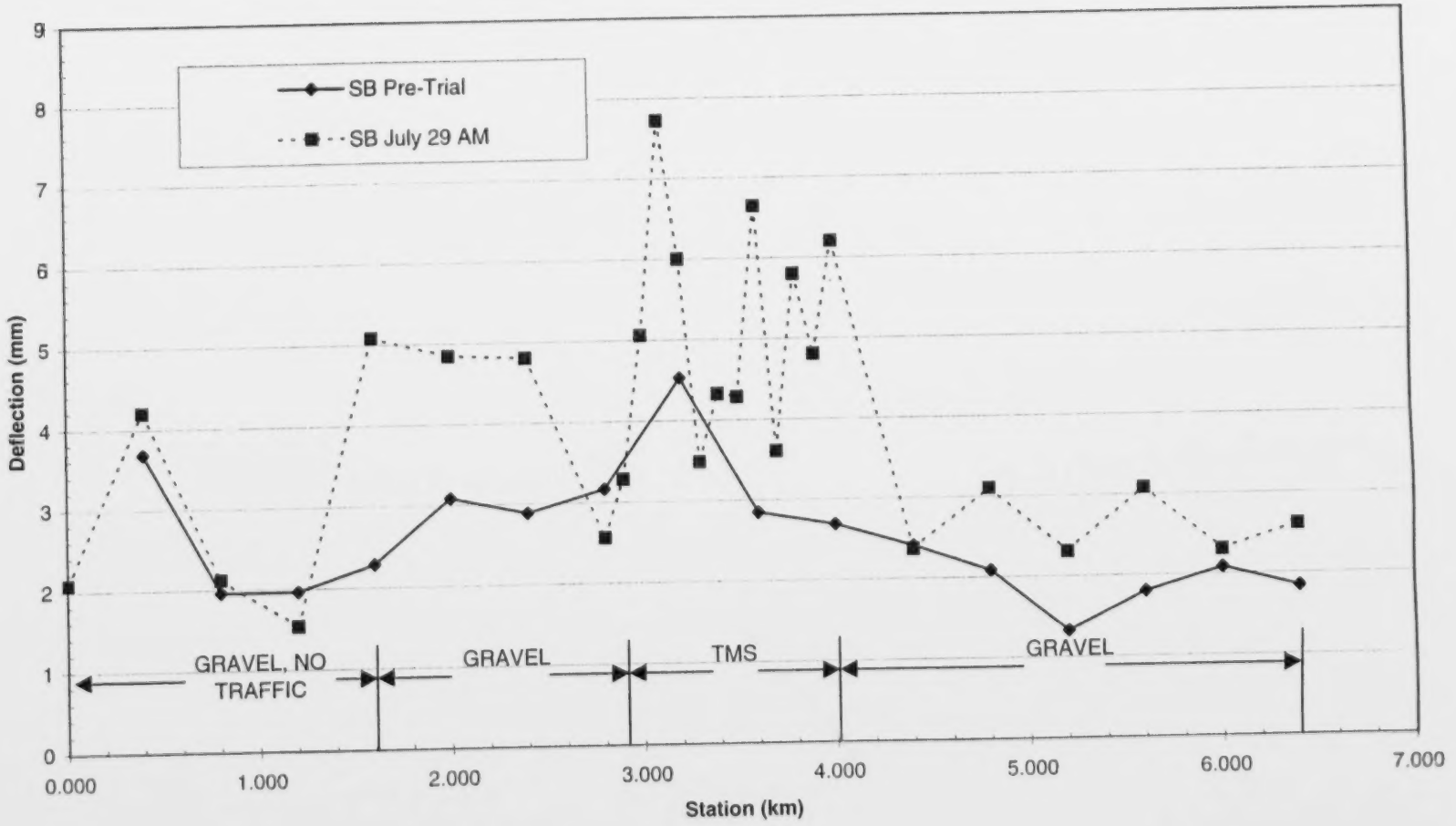


Figure 4-20
Average Daily Deflections - Southbound Lane, Road 103



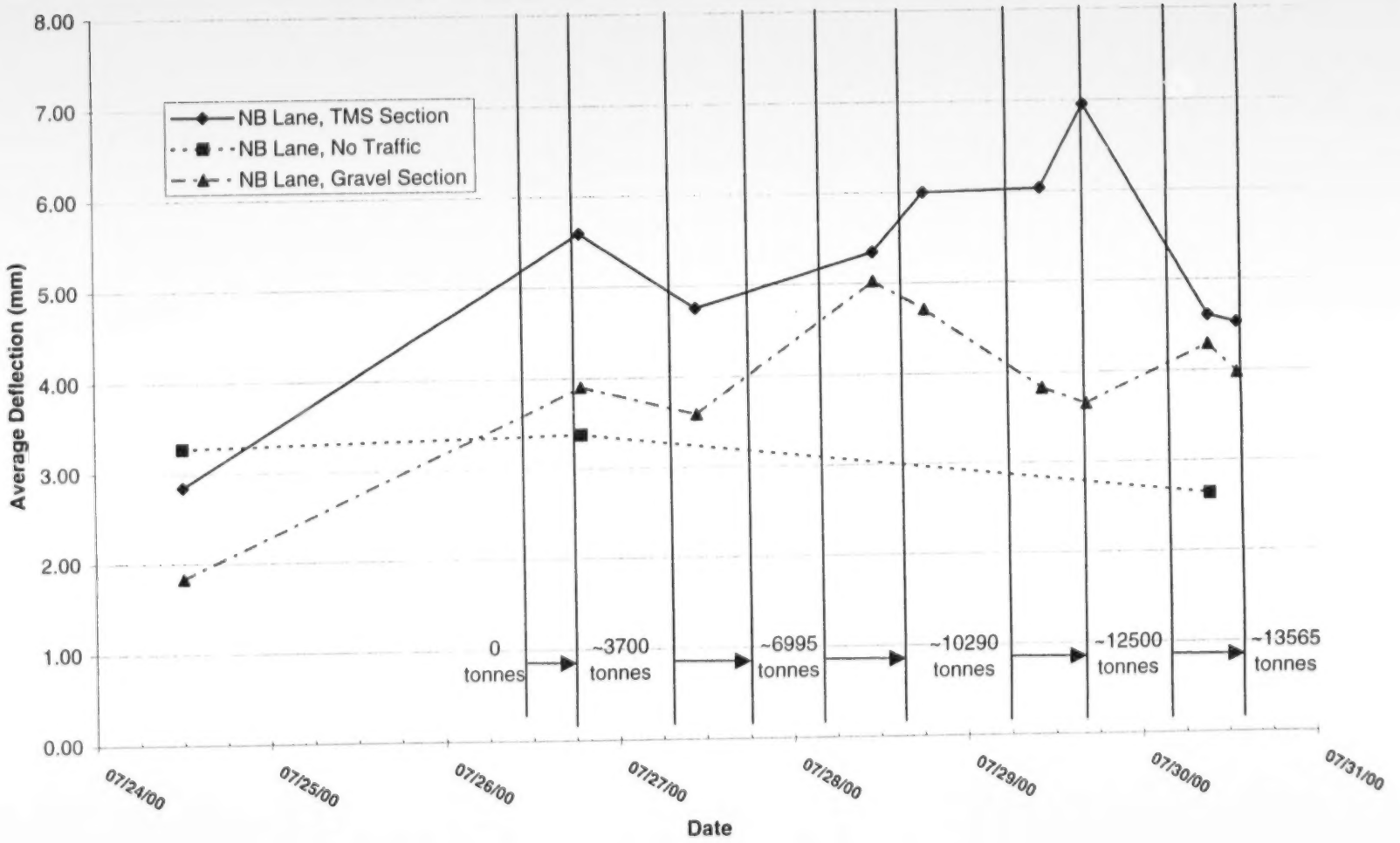
ROAD103AVERAGES

Figure 4-21
Comparison Deflections - Road 103
Southbound (Low Tire Pressure) Lane



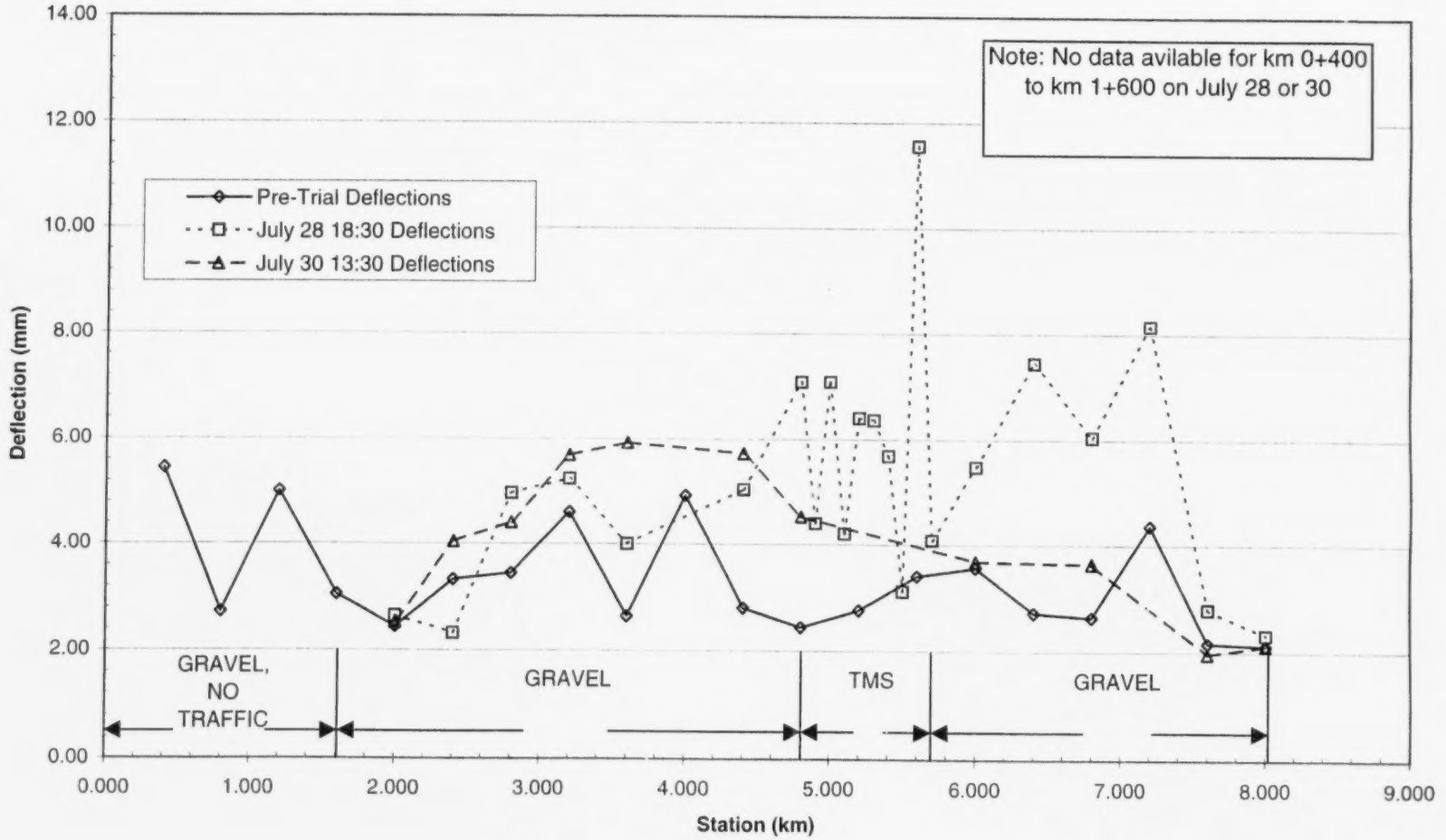
Road 103 Comparison Charts

Figure 4-22
Average Daily Deflections - Northbound Lane, Test Road 202



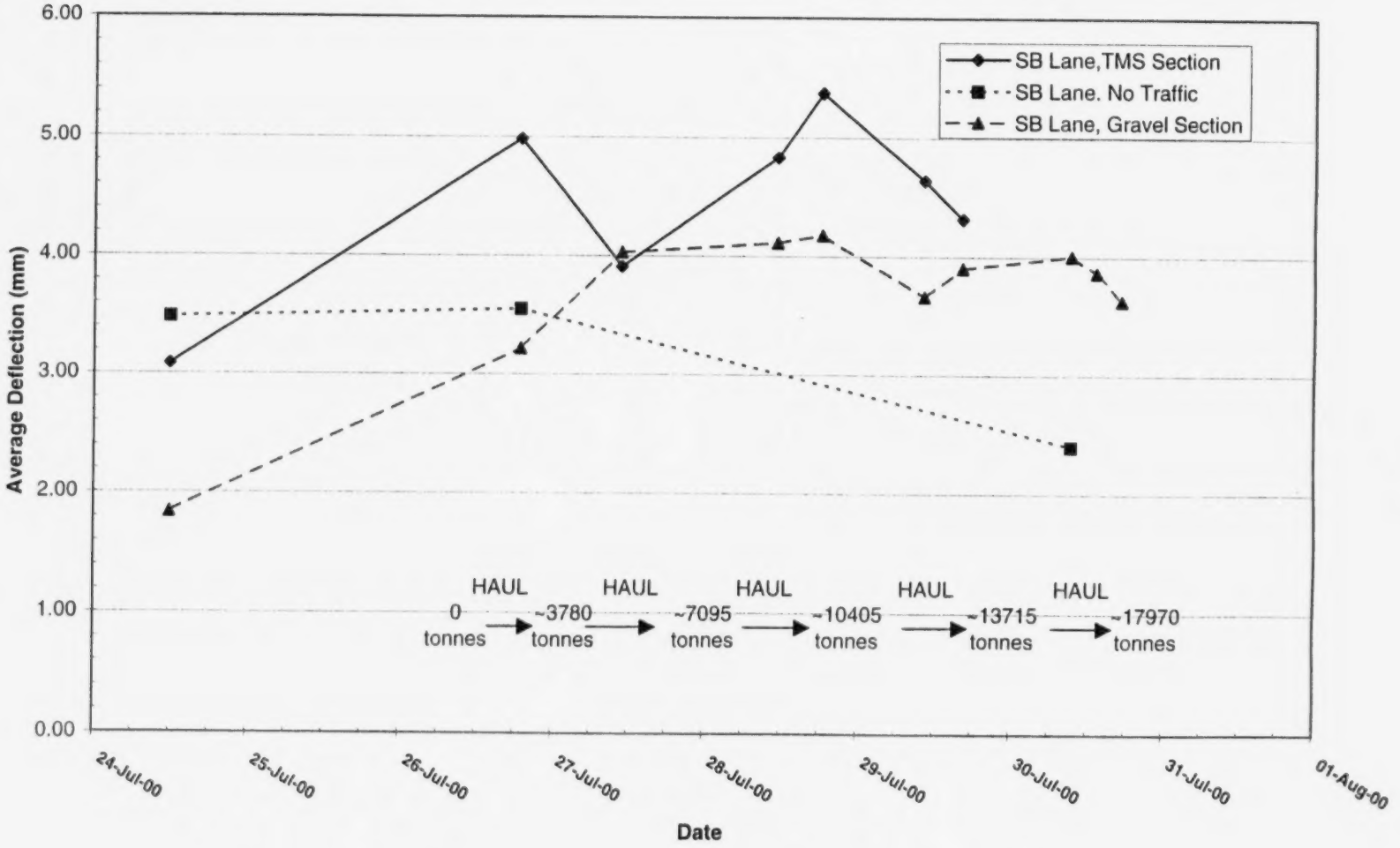
ROAD202AVERAGES

Figure 4-23
Comparison Deflections - Test Road 202
Northbound (High Tire Pressure) Lane



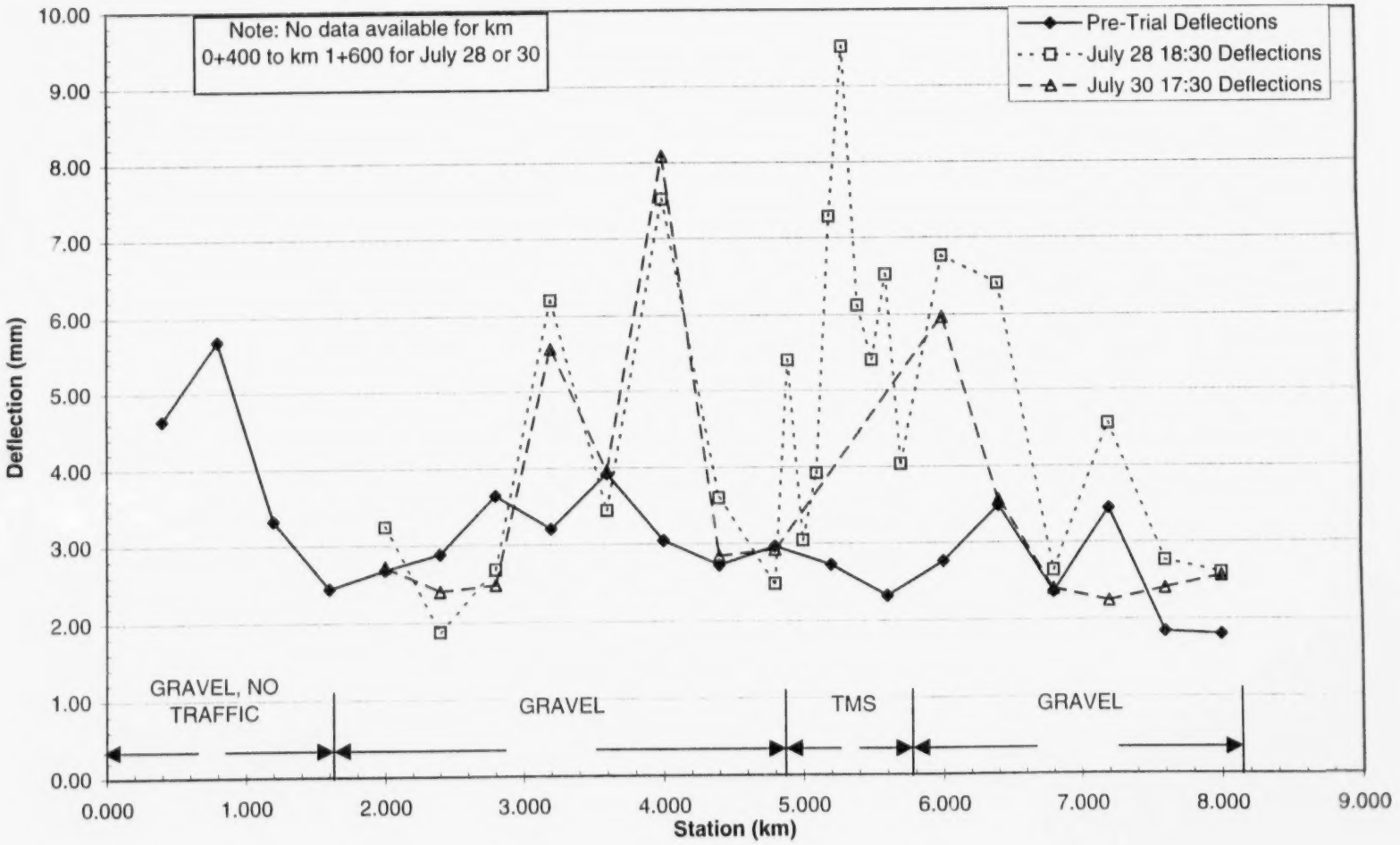
Road 202 Comparison

Figure 4-24
Average Daily Deflections - Southbound Lane, Test Road 202



ROAD202AVERAGES

Figure 4-25
Comparison Deflections - Test Road 202
Southbound (Low Tire Pressure) Lane



Road 202 Comparison

Figure 4-26
Deflection vs. Payload @ Station 2+000, Road 103

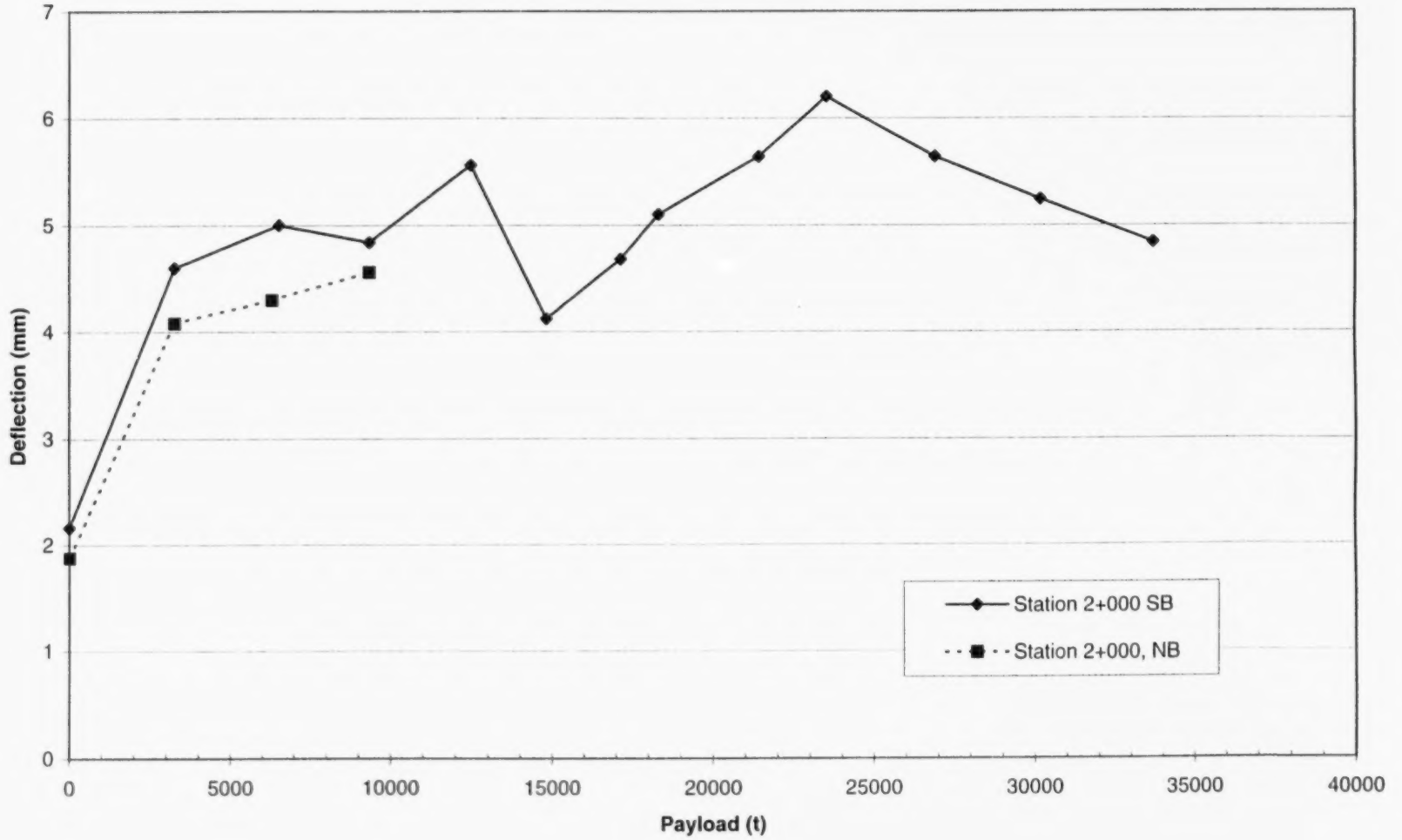


Figure 4-27
Deflection vs. Payload @ Station 4+000, Road 103

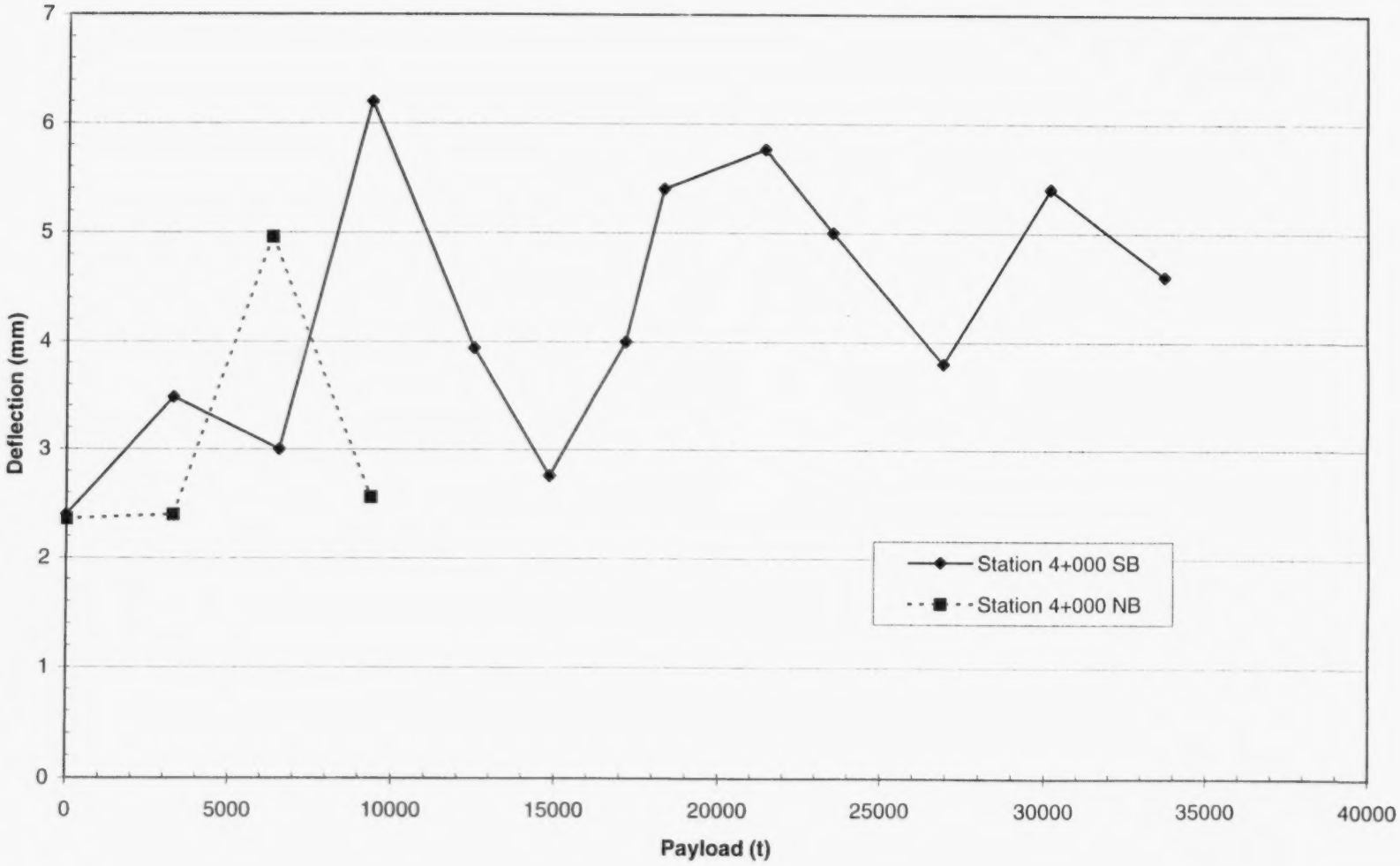


Figure 4-28
Deflection vs. Payload @ Station 6+000, Road 103

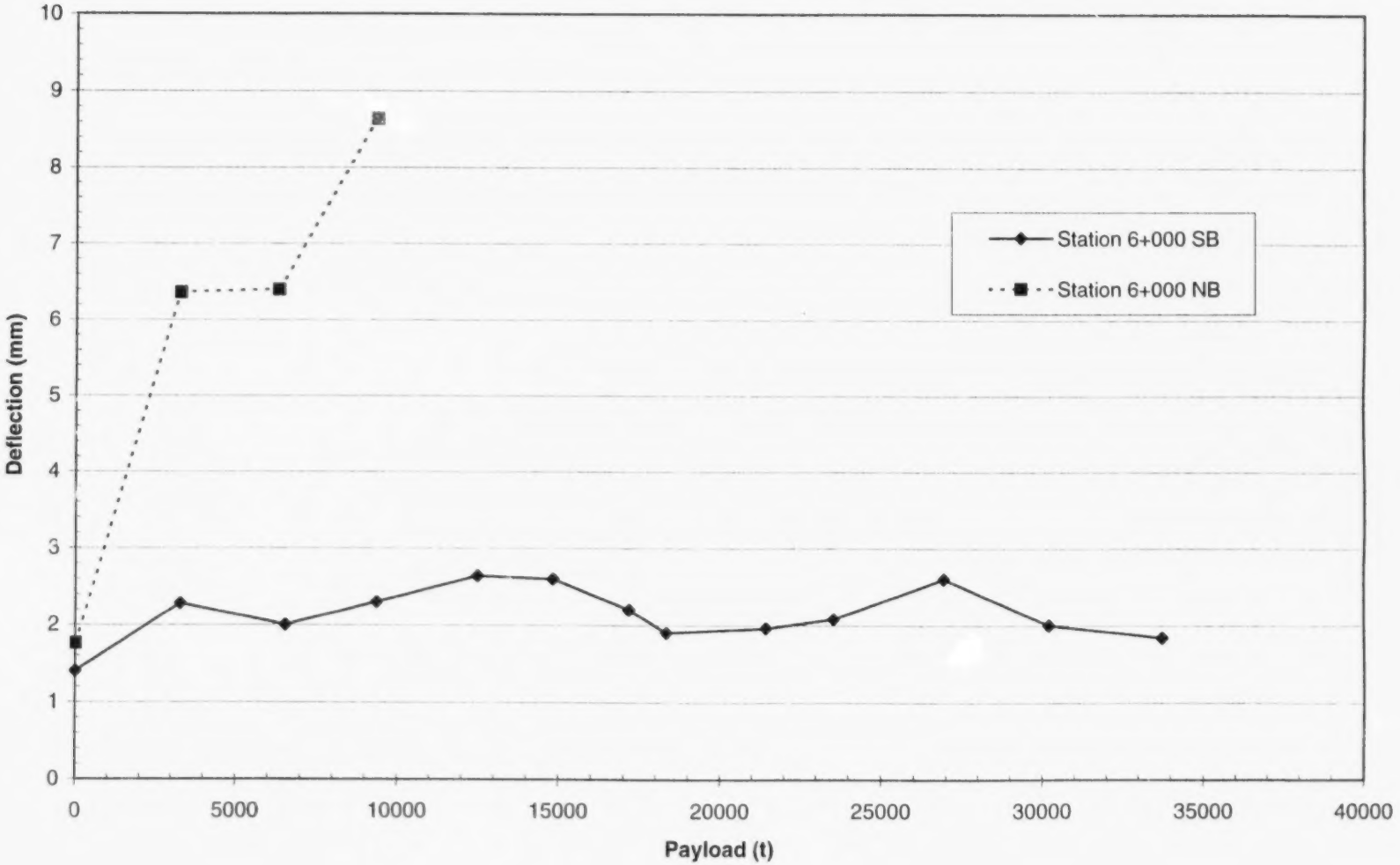


Figure 4-29
Deflection vs. Payload @ Station 2+000, Road 202

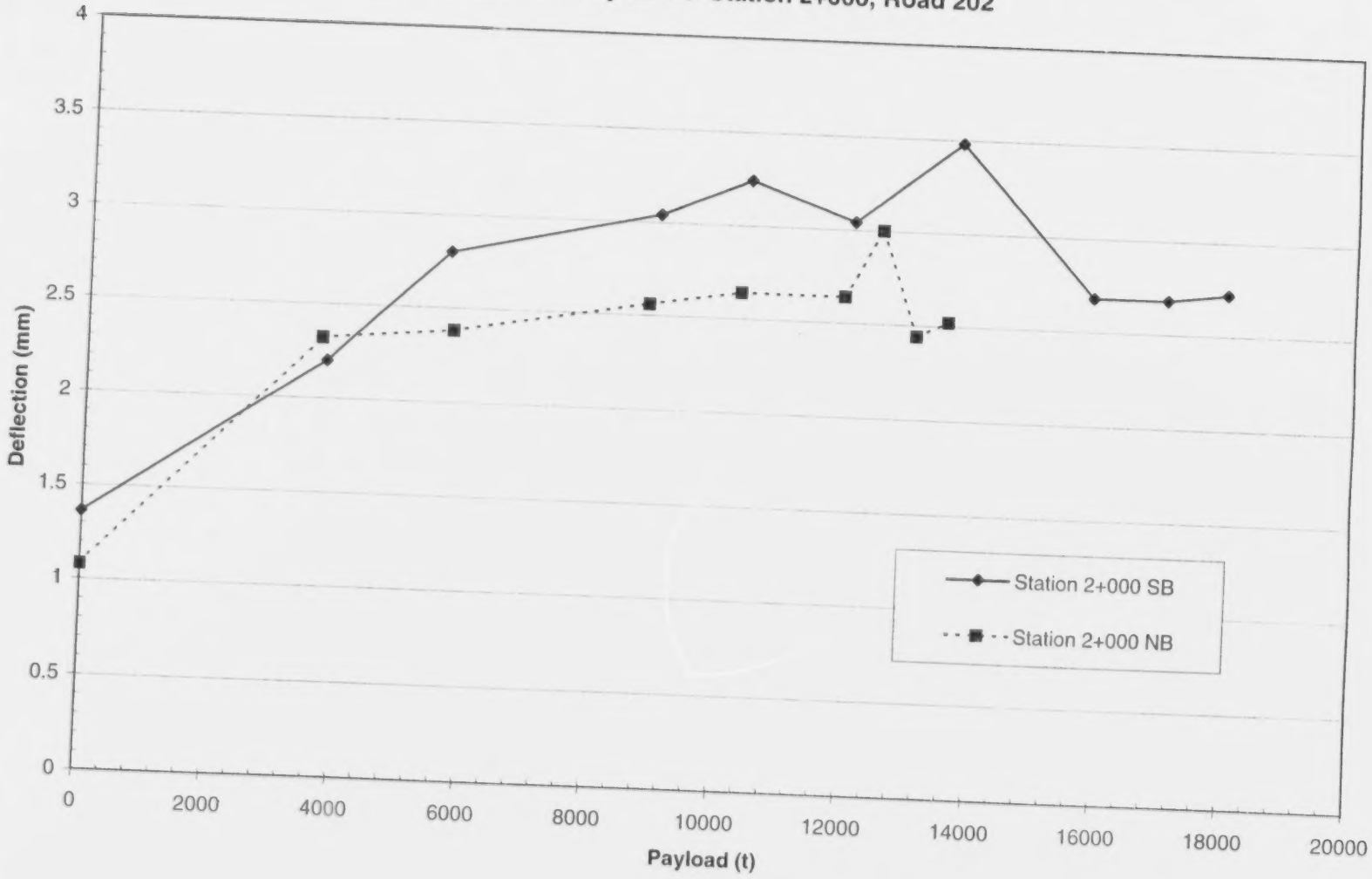


Figure 4-30
Deflection vs. Payload @ Station 3+600, Road 202

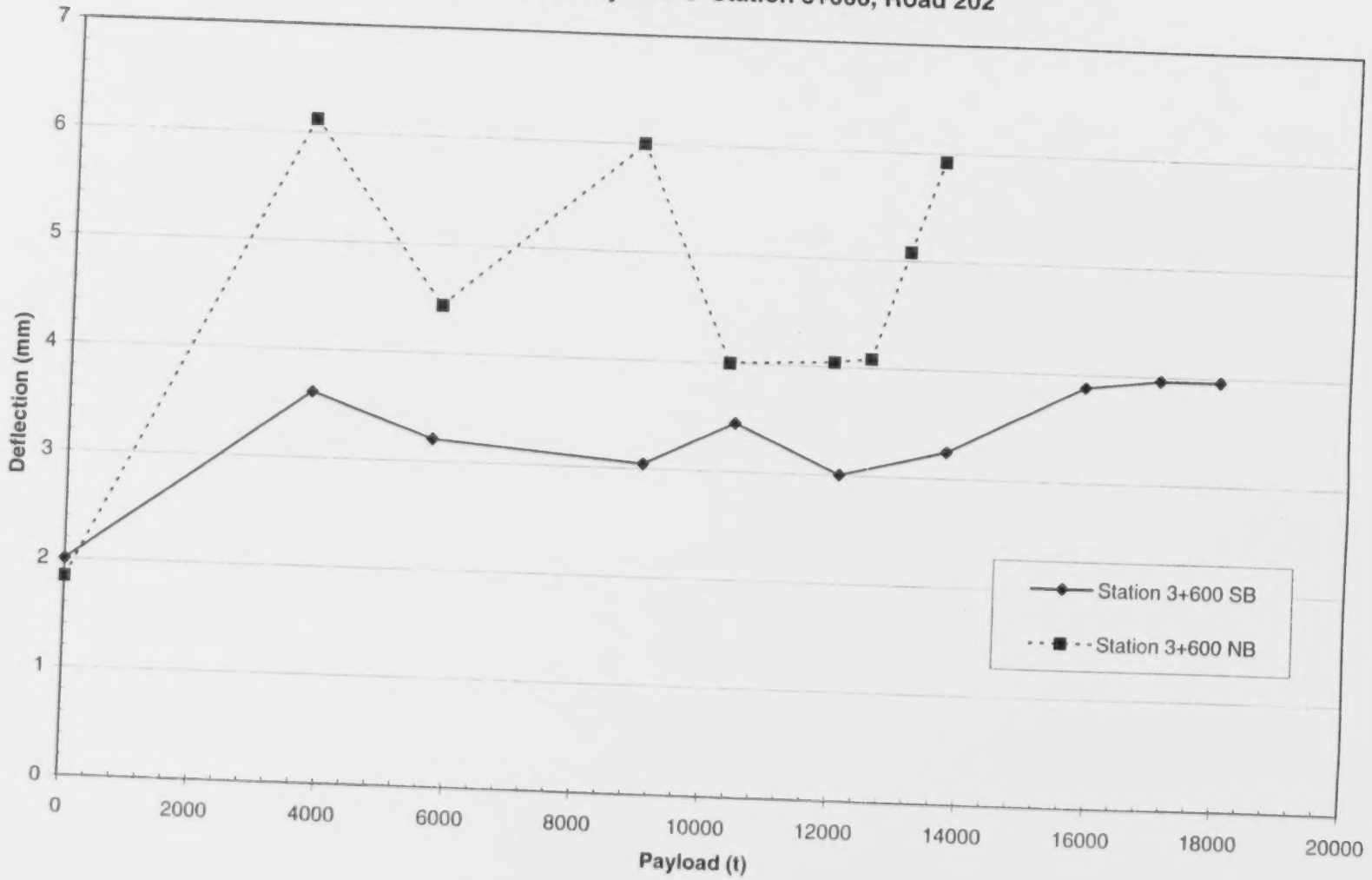


Figure 4-31
Deflection vs. Payload @ Station 6+000, Road 202

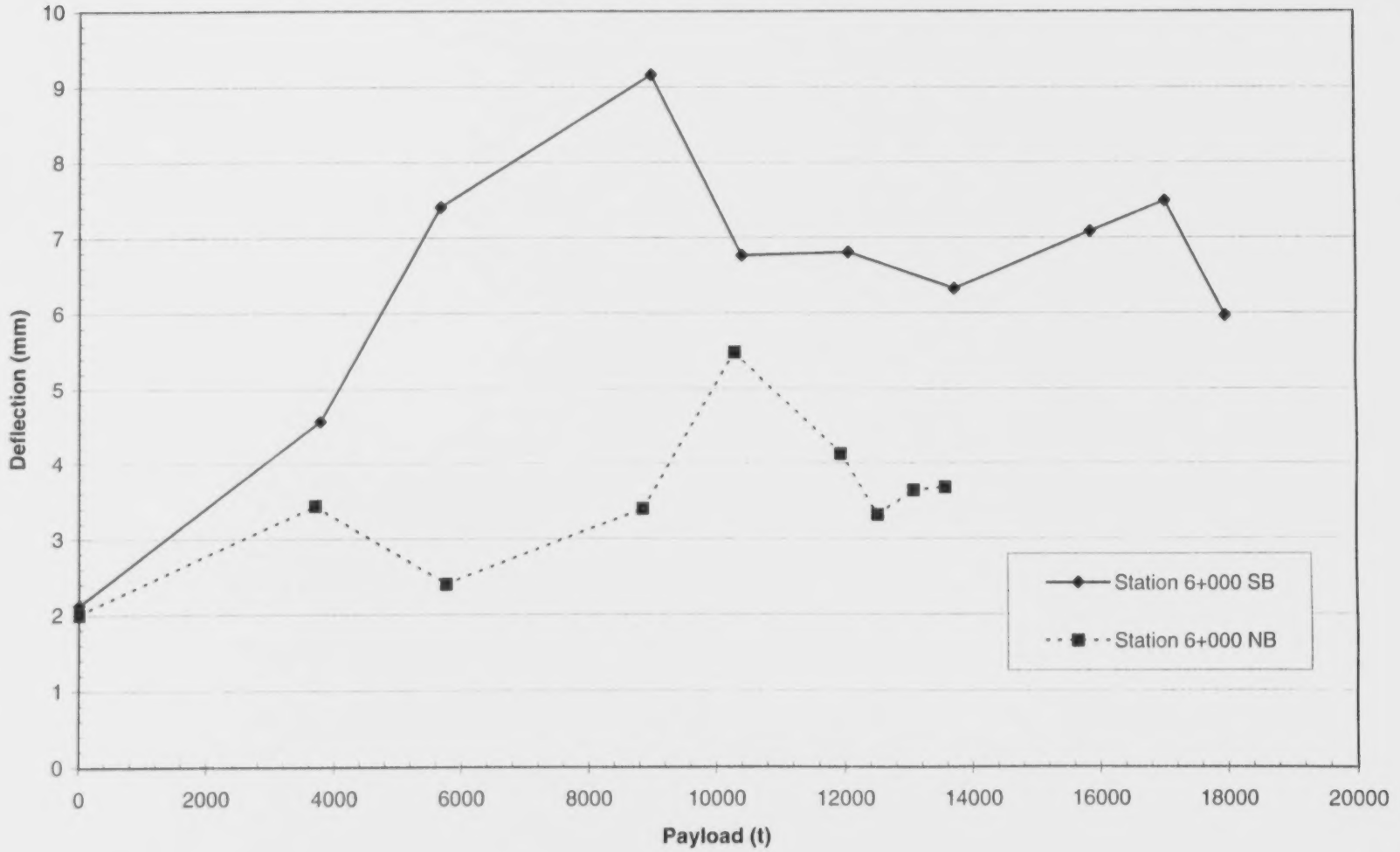


Figure 4-32
Deflection vs. Payload @ Station 8+000, Road 202

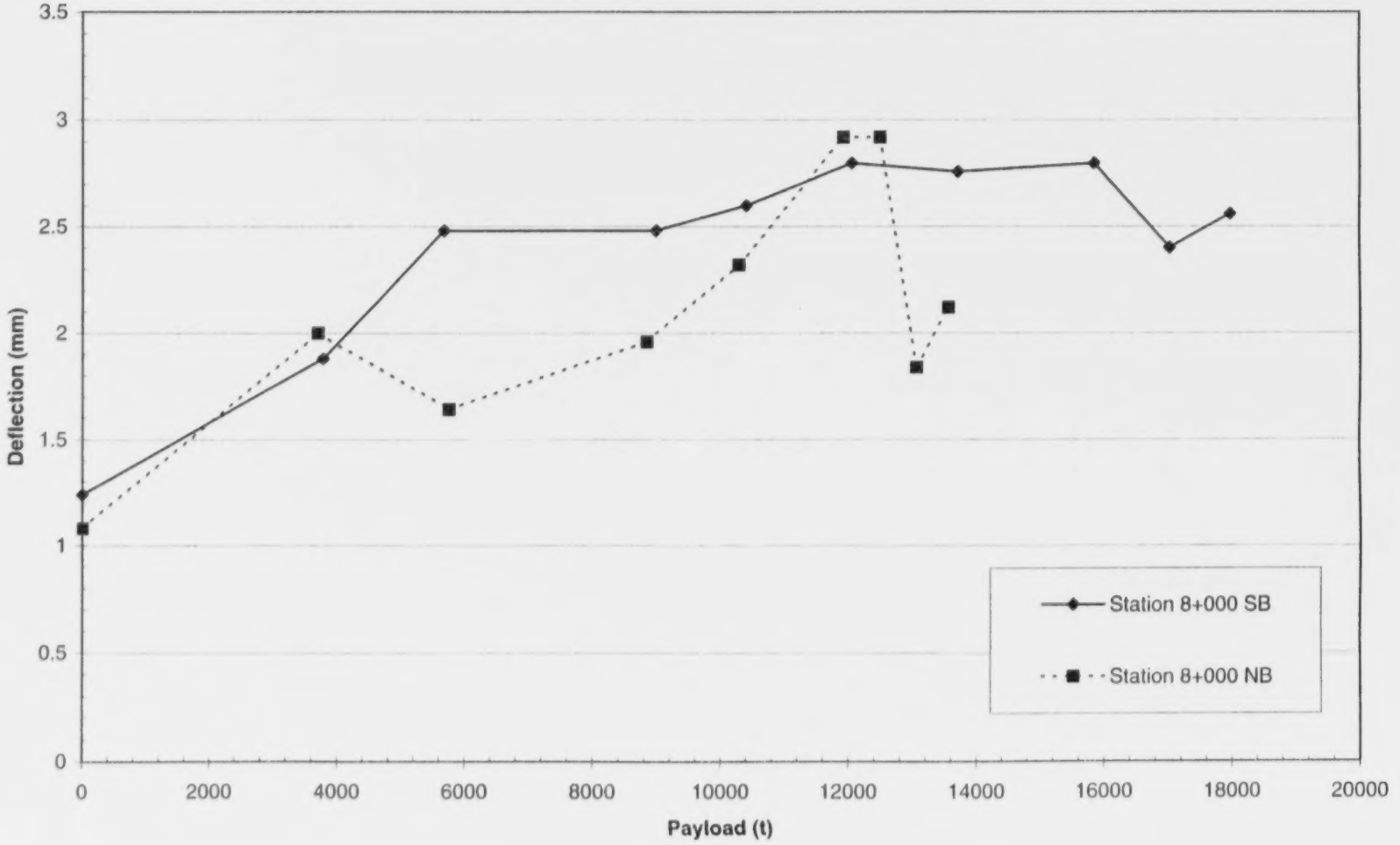
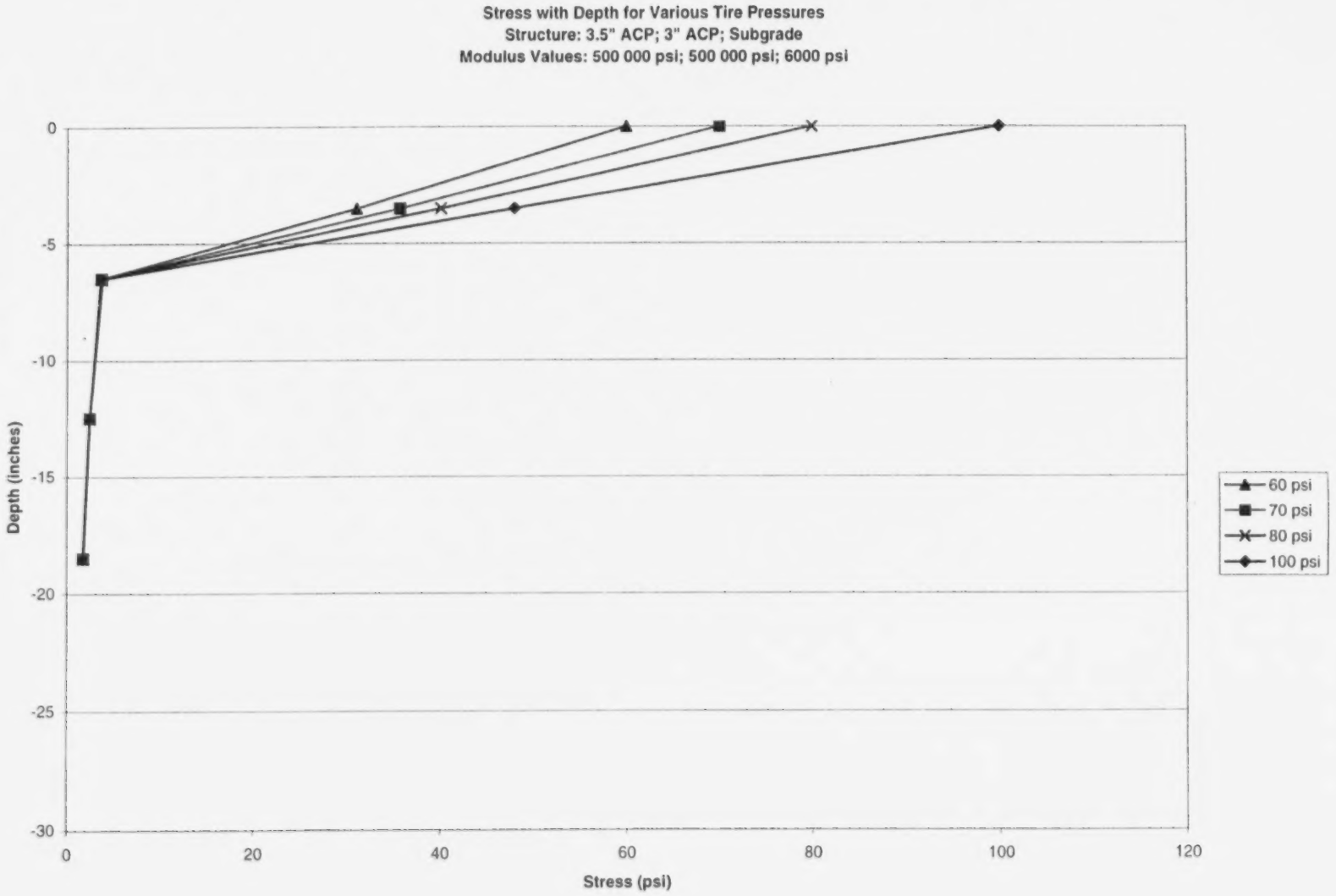
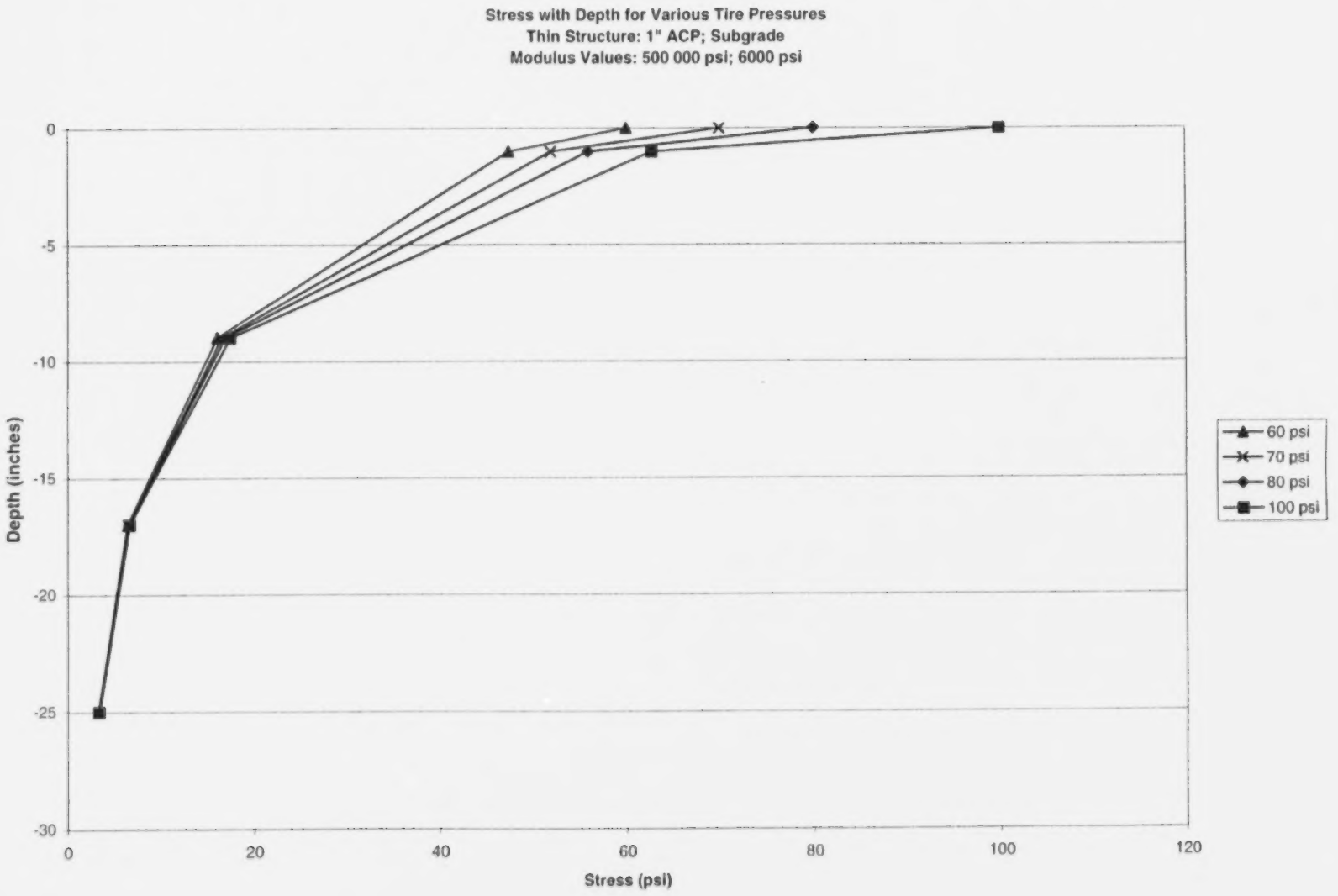


Figure 7-1



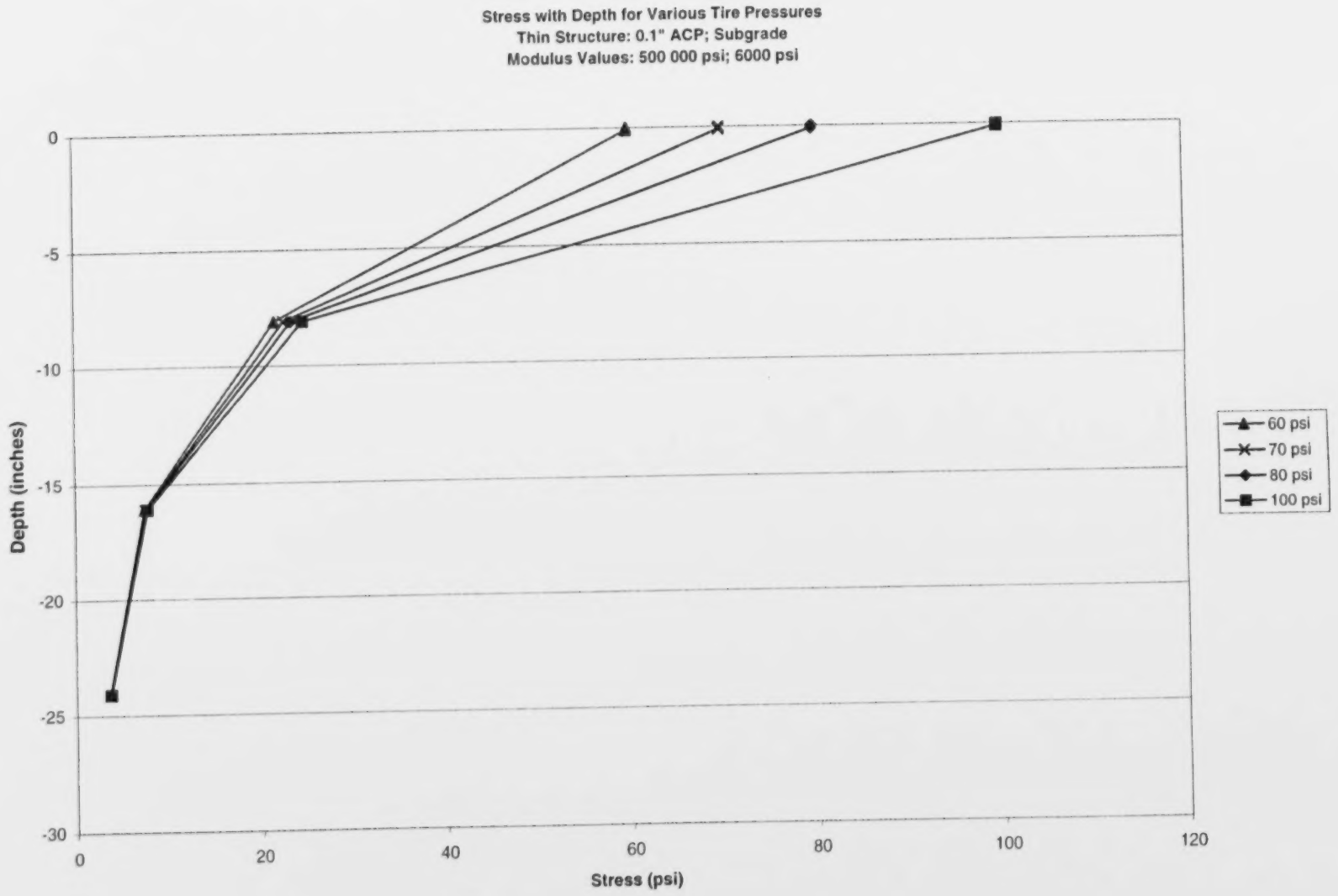
Stress Plots

Figure 7-2



Stress Plots

Figure 7-3



Stress Plots

Figure 7-4
Deflection Bowl Plots

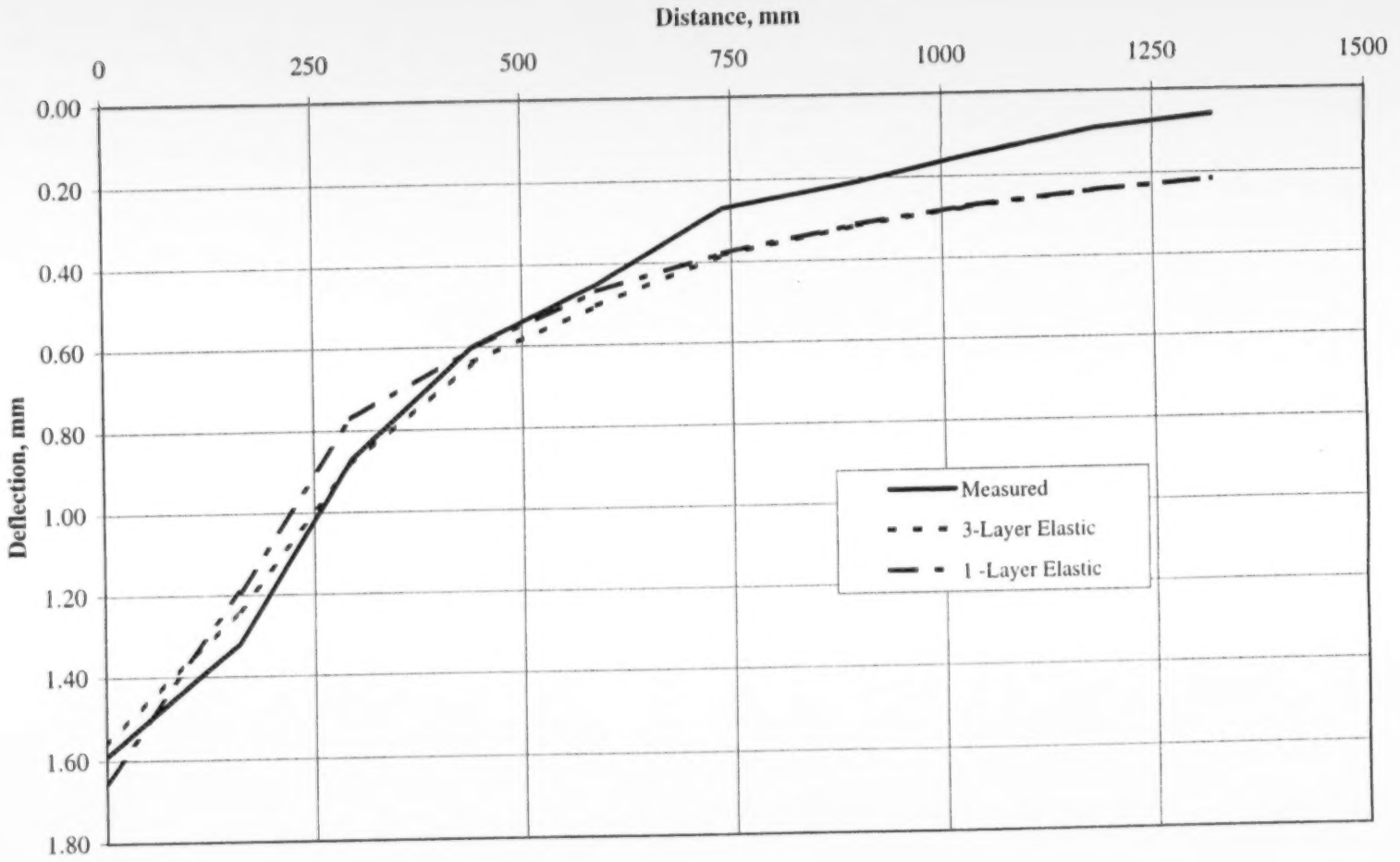
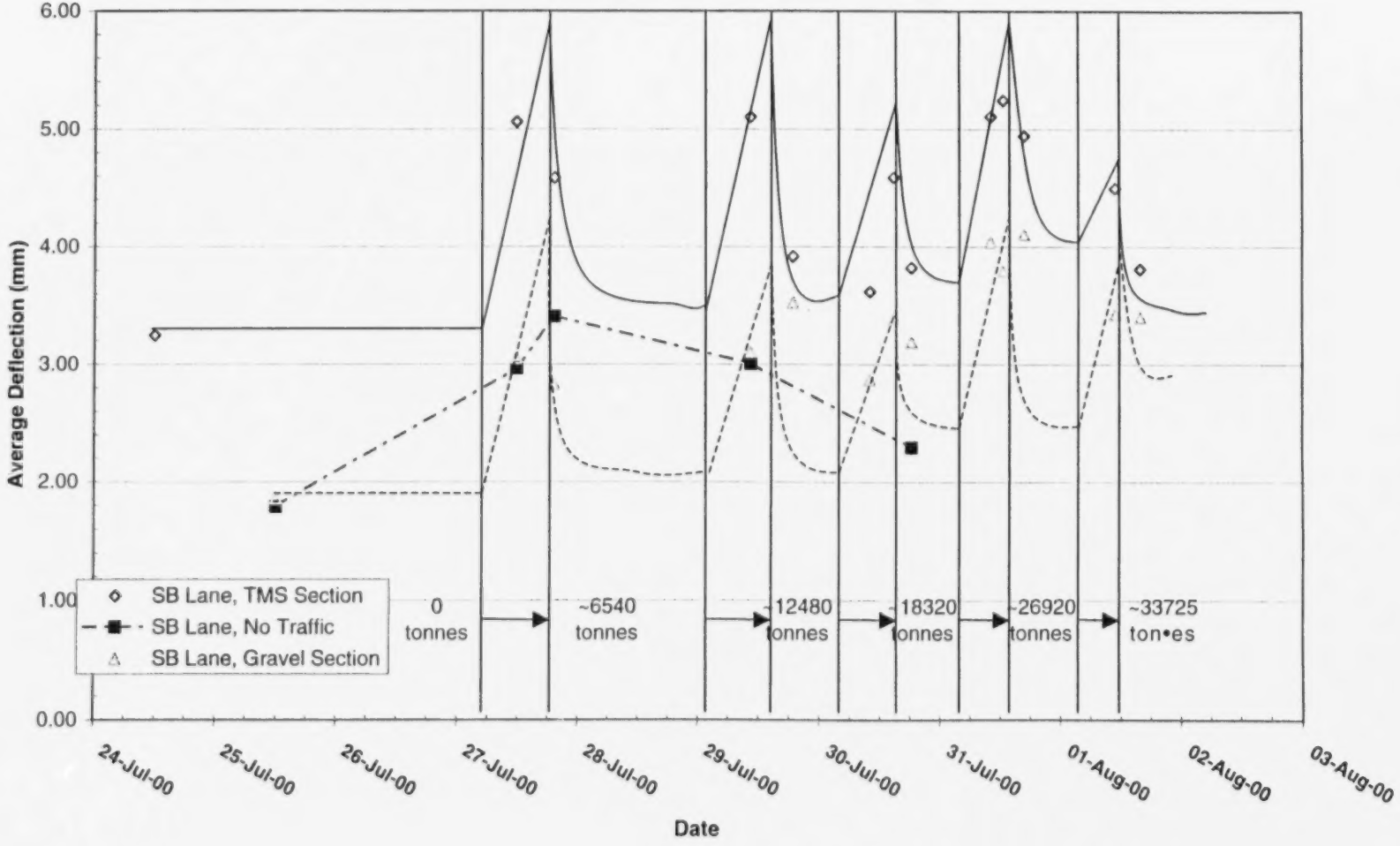
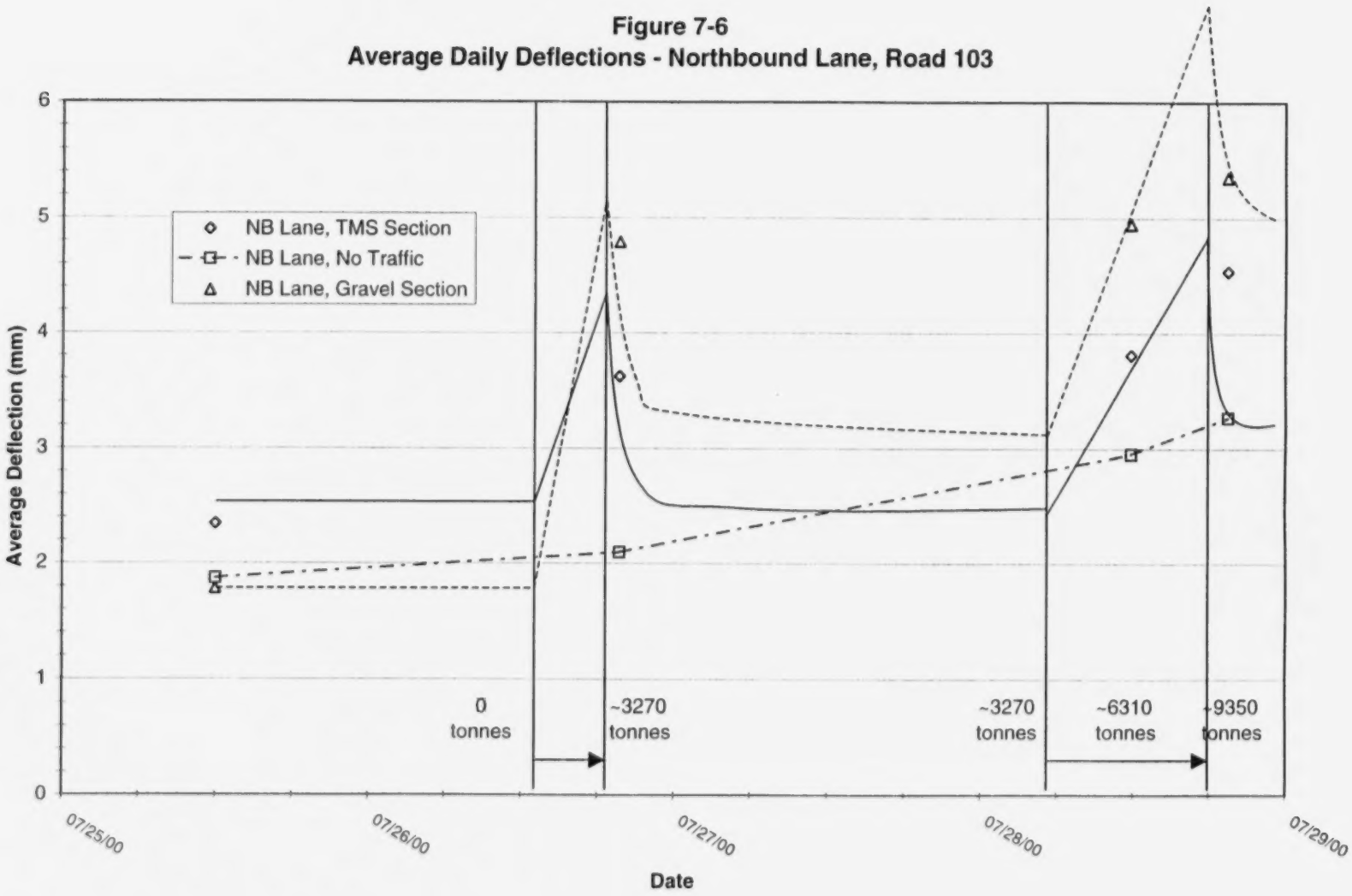


Figure 7-5
Average Daily Deflections - Southbound Lane, Road 103



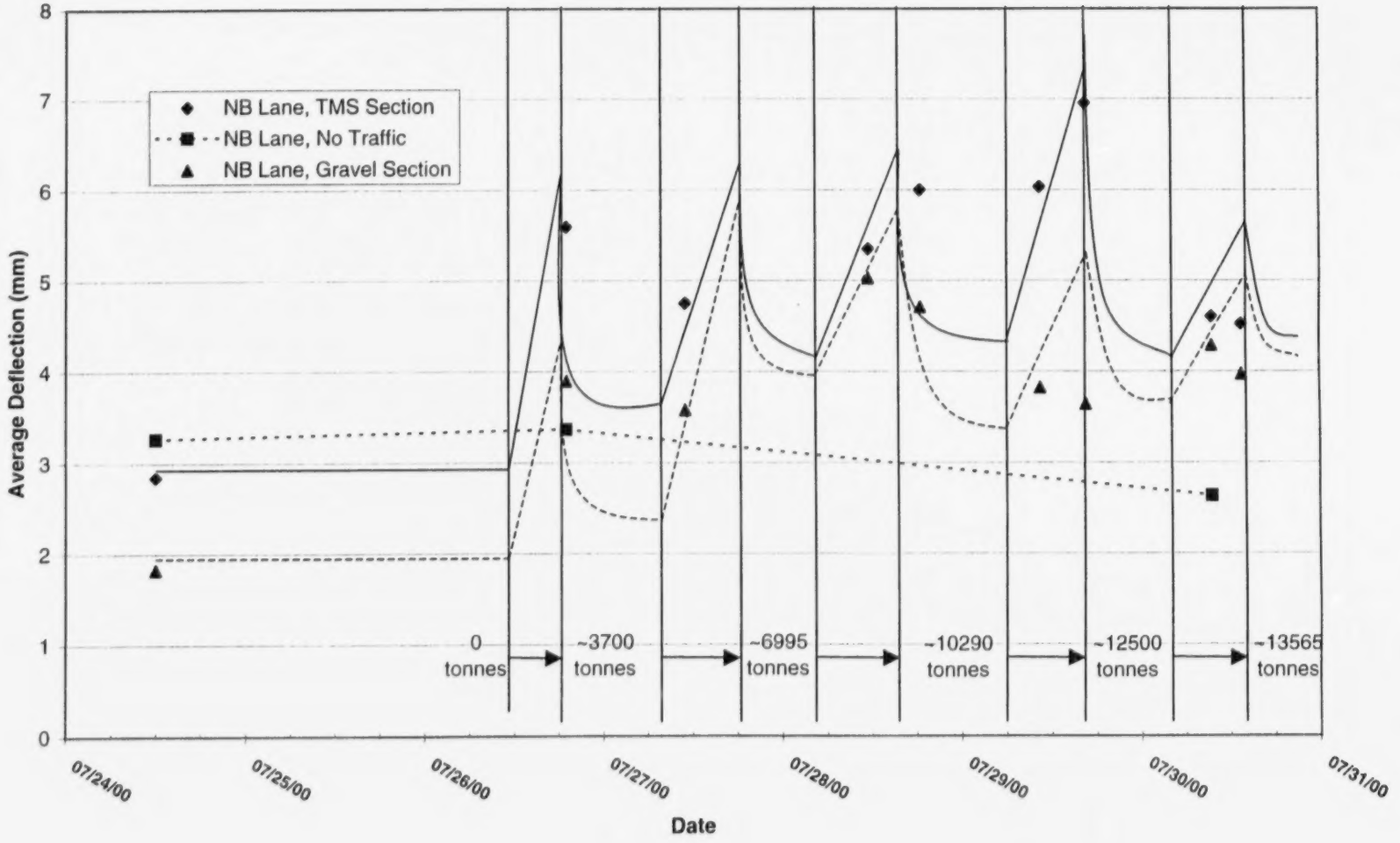
104-22951 plots

Figure 7-6
Average Daily Deflections - Northbound Lane, Road 103



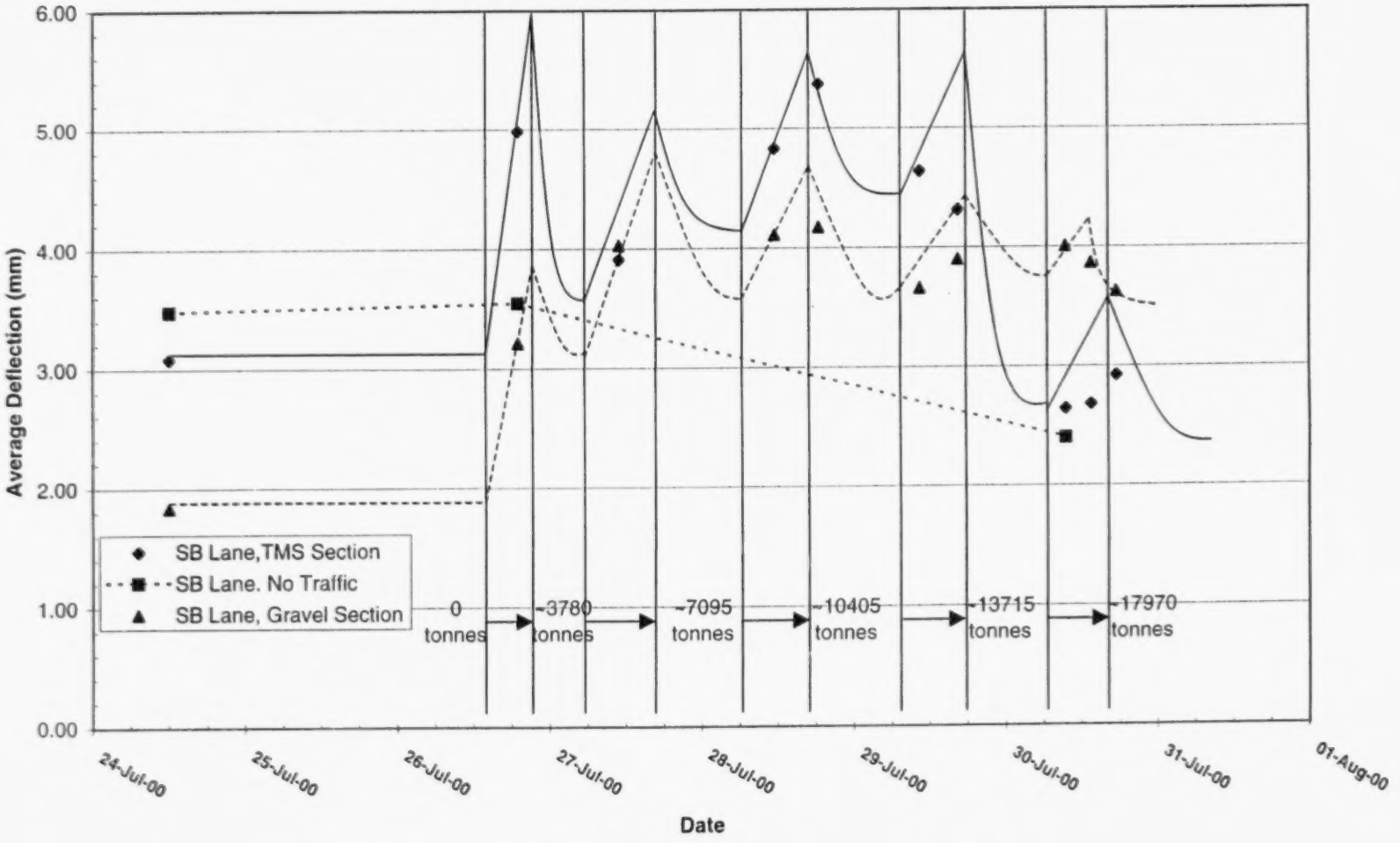
104-22951 plots

Figure 7-7
Average Daily Deflections - Northbound Lane, Road 202



104-22951 plots

Figure 7-8
Average Daily Deflections - Southbound Lane, Road 202



ROAD202AVERAGES

APPENDIX A

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APPENDIX B

TABLES

Table B-1; Soil characteristics at 2 depths in the low and high tire pressure lanes

LOW PRESSURE (Southbound)											HIGH PRESSURE (Northbound)										
Sample Data				Soil Properties/Classification							Sample Data				Soil Properties/Classification						
Test Hole#	Station	Offset (from centreline)	Depth(m)	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Unified Classification	Group Index	Soil Type	Test Hole#	Station	Offset (from centreline)	Depth(m)	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Unified Classification	Group Index	Soil Type
103-2	0+200	1.8 L	0.3	12.1	32	16	16	CI	8	Sandy Clay	103-1	0+200	1.8 R	0.3	13.7	37	18.0	19.0	CI	9	Sandy Clay
103-4	0+400	1.8 L	0.3	14.7	28	17	11	CL	6	Sandy Clay	103-3	0+400	1.8 R	0.3	13.3	35	16.1	18.9	CI	10	Low Plastic Clay
103-6	0+600	1.8 L	0.3	12.4	28	18	10	CL	3	Sandy Silt	103-5	0+600	1.8 R	0.3	16.7	31	17.0	14.0	CI	6	Sandy Clay
103-8	0+800	1.8 L	0.3	12.4	30	18	12	CI	5	Sandy Clay	103-7	0+800	1.8 R	0.3	13.9	26	17.0	9.0	CL	5	Sandy Silt
103-10	1+000	1.8 L	0.3	21.6	41	25	16	CI	8	Sandy Clay	103-9	1+000	1.8 R	0.3	17.7	42	25.2	16.8	CI	11	High Plastic Clay
103-12	1+200	1.8 L	0.3	12.4	30	17	13	CI	9	Low Plastic Clay	103-11	1+200	1.8 R	0.3	11.7	31	18.0	13.0	CI	7	Low Plastic Clay
103-14	1+400	1.8 L	0.3	12.2	31	17	14	CI	5	Sandy Clay	103-13	1+400	1.8 R	0.3	10.5	30	17.0	13.0	CI	8	Low Plastic Clay
103-16	1+600	1.8 L	0.3	16.2	36	18	18	CI	11	Low Plastic Clay	103-15	1+600	1.8 R	0.3	17.2	37	16.5	20.5	CI	12	Low Plastic Clay
103-18	1+800	1.8 L	0.3	12.4	42	16	26	CI	12	Sandy Clay	103-17	1+800	1.8 R	0.3	11.8	38	16.1	21.9	CI	10	Sandy Clay
103-20	2+000	1.8 L	0.3	11.8	36	16	20	CI	5	Sandy Clay	103-19	2+000	1.8 R	0.3	12.3	38	17.0	21.0	CI	10	Sandy Clay
103-22	2+200	1.8 L	0.3	14.1	40	15	25	CI	12	Sandy Clay	103-21	2+200	1.8 R	0.3	13.7	37	15.4	21.6	CI	10	Sandy Clay
103-24	2+400	1.8 L	0.3	14.6	41	16	25	CI	12	Sandy Clay	103-23	2+300	1.8 R	0.3	13.6	39	15.9	23.1	CI	12	Low Plastic Clay
103-26	2+600	1.8 L	0.3	13.9	45	15	30	CI	14	Sandy Clay	103-25	2+600	1.8 R	0.3	11.2	37	16.0	21.0	CI	10	Sandy Clay
103-28	2+800	1.8 L	0.3	12.1	36	16	20	CI	8	Sandy Clay	103-27	2+800	1.8 R	0.3	11.9	40	16.0	24.0	CI	10	Sandy Clay
103-30	3+000	1.8 L	0.3	12.8	36	15	21	CI	9	Sandy Clay	103-29	3+000	1.8 R	0.3	12.4	33	15.0	18.0	CI	6	Sandy Clay
103-32	3+200	1.8 L	0.3	19.4	42	16	26	CI	13	Sandy Clay	103-31	3+200	1.8 R	0.3	12.4	35	15.0	20.0	CI	9	Sandy Clay
103-34	3+400	1.8 L	0.3	10.2	34	15	19	CI	9	Sandy Clay	103-33	3+300	1.8 R	0.3	12.5	35	14.0	21.0	CI	11	Low Plastic Clay
103-36	3+600	1.8 L	0.3	12.1	39	12	27	CI	13	Low Plastic Clay	103-35	3+600	1.8 R	0.3	9.6	37	14.0	23.0	CI	8	Sandy Clay
103-38	3+800	1.8 L	0.3	12.0	37	15	22	CI	10	Sandy Clay	103-37	3+800	1.8 R	0.3	11.9	41	14.8	26.2	CI	13	High Plastic Clay
103-40	4+00	1.8 L	0.3	12.0	38	15	23	CI	11	Sandy Clay	103-39	4+000	1.8 R	0.3	12.5	42	15.0	27.0	CI	13	High Plastic Clay
103-42	4+200	1.8 L	0.3	13.6	38	15	23	CI	12	Low Plastic Clay	103-41	4+200	1.8 R	0.3	12.7	36	15.1	20.9	CI	11	Low Plastic Clay
103-44	4+400	1.8 L	0.3	12.3	36	17	19	CI	12	Low Plastic Clay	103-43	4+400	1.8 R	0.3	12.9	35	16.9	18.1	CI	11	Low Plastic Clay
103-46	4+600	1.8 L	0.3	12.4	33	18	15	CI	9	Low Plastic Clay	103-45	4+600	1.8 R	0.3	14.3	37	17.0	20.0	CI	12	Low Plastic Clay
103-48	4+800	1.8 L	0.3	13.5	38	16	22	CI	12	Low Plastic Clay	103-47	4+800	1.8 R	0.3	14.8	35	17.0	18.0	CI	11	Low Plastic Clay
103-50	5+000	1.8 L	0.3	13.7	41	18	23	CI	12	High Plastic Clay	103-49	5+000	1.8 R	0.3	12.4	37	17.9	19.1	CI	10	Low Plastic Clay
103-52	5+200	1.8 L	0.3	14.8	36	16	20	CI	10	Low Plastic Clay	103-51	5+200	1.8 R	0.3	11.2	31	16.0	15.0	CI	7	Sandy Clay
103-54	5+400	1.8 L	0.3	11.8	37	15	22	CI	10	Sandy Clay	103-53	5+400	1.8 R	0.3	12.7	44	17.0	27.0	CI	15	High Plastic Clay
103-56	5+600	1.8 L	0.3	13.1	41	15	26	CI	13	High Plastic Clay	103-55	5+600	1.8 R	0.3	14.1	41	16.0	25.0	CI	12	High Plastic Clay
103-58	5+800	1.8 L	0.3	11.3	33	16	17	CI	9	Low Plastic Clay	103-57	5+800	1.8 R	0.3	13.8	33	15.7	17.3	CI	9	Low Plastic Clay
103-60	6+000	1.8 L	0.3	10.0	30	15	15	CI	7	Sandy Clay	103-59	6+000	1.8 R	0.3	11.5	31	15.0	16.0	CI	10	Low Plastic Clay
103-62	6+200	1.8 L	0.3	8.2	33	14	19	CI	8	Sandy Clay	103-61	6+200	1.8 R	0.3	11.0	30	15.5	14.5	CI	5	Sandy Clay
103-64	6+400	1.8 L	0.3	11.2	36	16	20	CI	11	Low Plastic Clay	103-63	6+400	1.8 R	0.3	9.8	31	15.8	15.2	CI	9	Low Plastic Clay
103-66	6+600	1.8 L	0.3	9.7	34	15	19	CI	11	Low Plastic Clay	103-65	6+600	1.8 R	0.3	9.8	30	15.0	15.0	CI	5	Sandy Clay
	Mean			12.93	36	16.19	19.81		9.76						12.77	35.52	16.33	19.19		9.73	
	Standard Deviation			2.528	4.345	1.977	4.887		2.63						1.933	4.236	1.91	4.294		0.51	
	Statistical Difference @ 95% Confidence			NO	NO	NO	NO		NO						NO	NO	NO	NO		NO	
	Number of Observatio			33	33	33	33	33	33						33	33	33	33	33	33	
103-2	0+200	1.8 L	0.6	16.2	37	20.0	17.0	CI	8	Sandy Clay	103-1	0+200	1.8 R	0.6	18.5	39	23.2	15.8	CI	8	Sandy Clay
103-4	0+400	1.8 L	0.6	18.4	40	24.0	16.0	CI	7	Sandy Clay	103-3	0+400	1.8 R	0.6	18.5	39	23.0	16.0	CI	8	Sandy Clay
103-6	0+600	1.8 L	0.6	13.4	33	18.0	15.0	CI	8	Sandy Clay	103-5	0+600	1.8 R	0.6	16.7	32	18.0	14.0	CI	8	Low Plastic Clay
103-8	0+800	1.8 L	0.6	19.0	36	22.8	13.2	CI	6	Sandy Clay	103-7	0+800	1.8 R	0.6	18.0	38	21.0	17.0	CI	9	Low Plastic Clay
103-10	1+000	1.8 L	0.6	15.8	37	18.2	18.8	CI	9	Sandy Clay	103-9	1+000	1.8 R	0.6	19.3	40	23.1	16.9	CI	8	Sandy Clay
103-12	1+200	1.8 L	0.6	12.1	27	16.0	11.0	CL	6	Low Plastic Clay	103-11	1+200	1.8 R	0.6	12.5	27	16.0	11.0	CL	5	Sandy Clay
103-14	1+400	1.8 L	0.6	16.4	39	23.3	15.7	CI	8	Sandy Clay	103-13	1+400	1.8 R	0.6	10.6	28	17.0	11.0	CL	4	Sandy Clay
103-16	1+600	1.8 L	0.6	21.0	41	22.0	19.0	CI	11	High Plastic Clay	103-15	1+600	1.8 R	0.6	19.0	33	21.3	11.7	CI	6	Sandy Clay
103-18	1+800	1.8 L	0.6	13.0	37	16.0	21.0	CI	11	Low Plastic Clay	103-17	1+800	1.8 R	0.6	15.3	38	20.0	18.0	CI	11	Low Plastic Clay
103-20	2+000	1.8 L	0.6	13.0	38	16.0	22.0	CI	10	Sandy Clay	103-19	2+000	1.8 R	0.6	13.9	37	17.0	20.0	CI	10	Low Plastic Clay
103-22	2+200	1.8 L	0.6	13.9	37	17.0	20.0	CI	11	Low Plastic Clay	103-21	2+200	1.8 R	0.6	29.6	44	22.7	21.3	CI	13	High Plastic Clay
103-24	2+400	1.8 L	0.6	15.2	40	17.0	23.0	CI	13	Low Plastic Clay	103-23	2+300	1.8 R	0.6	19.9	36	21.5	14.5	CI	6	Sandy Clay
103-26	2+600	1.8 L	0.6	13.1	33	15.0	18.0	CI	10	Low Plastic Clay	103-25	2+600	1.8 R	0.6	13.3	36	16.0	20.0	CI	11	Low Plastic Clay
103-28	2+800	1.8 L	0.6	12.5	38	15.3	22.7	CI	10	Sandy Clay	103-27	2+800	1.8 R	0.6	12.4	34	16.0	18.0	CI	9	Sandy Clay
103-30	3+000	1.8 L	0.6	22.0	38	22.6	15.4	CI	8	Sandy Clay	103-29	3+000	1.8 R	0.6	21.8	31	18.6	12.4	CI	4	Sandy Clay
103-32	3+200	1.8 L	0.6	21.9	39	21.0	18.0	CI	9	Sandy Clay	103-31	3+200	1.8 R	0.6	21.8	43	18.0	25.0	CI	15	High Plastic Clay
103-34	3+400	1.8 L	0.6	14.5	34	15.8	18.2	CI	11	Low Plastic Clay	103-33	3+300	1.8 R	0.6	15.8	37	16.0	21.0	CI	10	Sandy Clay
103-36	3+600	1.8 L	0.6	14.0	32	16.3	15.7	CI	8	Low Plastic Clay	103-35	3+600	1.8 R	0.6	15.2	36	16.9	19.1	CI	12	Low Plastic Clay
103-38	3+800	1.8 L	0.6	14.8	36	19.0	17.0	CI	10	Low Plastic Clay	103-37	3+800	1.8 R	0.6	13.9	34	17.0	17.0	CI	8	Sandy Clay
103-40	4+00	1.8 L	0.6	13.0	38	16.0	22.0	CI	11	Low Plastic Clay	103-39	4+000	1.8 R	0.6	14.1	37	16.0	21.0	CI	11	Low Plastic Clay
103-42	4+200	1.8 L	0.6	14.7	36	16.6	19.4	CI	9	Sandy Clay	103-41	4+200	1.8 R	0.6	14.5	34	16.9	17.1	CI	10	Low Plastic Clay
103-44	4+400	1.8 L	0.6	16.7	36	17.0	19.0	CI	12	Low Plastic Clay	103-43	4+400	1.8 R	0.6	16.9	45	19.1	25.9	CI	15	High Plastic Clay
103-46	4+600	1.8 L	0.6	13.1	37	20.0	17.0	CI	11	Low Plastic Clay	103-45	4+600	1.8 R	0.6	11.4	36	17.0	19.0	CI	9	Sandy Clay
103-48	4+800	1.8 L	0.6	17.4	36	18.4	17.6	CI	10	Low Plastic Clay	103-47	4+800	1.8 R	0.6	13.1	28	17.0	11.0	CL	7	Low Plastic Clay
103-50	5+000	1.8 L	0.6	11.9	40	17.2	22.8	CI	12	Low Plastic Clay	103-49	5+000	1.8 R	0.6	12.8	39	17.7	21.3	CI	12	Low Plastic Clay
103-52	5+200	1.8 L	0.6	14.5	32	16.0	16.0	CI	10	Low Plastic Clay	103-51	5+200	1.8 R	0.6	13.2	38	17.0	21.0	CI	12	Low Plastic Clay
103-54	5+400	1.8 L	0.6	14.9	39	17.5	21.5	CI	12	Low Plastic Clay	103-53	5+400	1.8 R	0.6	14.1	36	17.0	19.0	CI	10	Low Plastic Clay
103-56	5+600	1.8 L	0.6	17.5	39	18.6	20.4	CI	12	Low Plastic Clay	103-55	5+600	1.8 R	0.6	16.5	40	16.8	23.2	CI	12	Low Plastic Clay
103-58	5+800	1.8 L	0.6	14.6	36	18.0	18.0	CI	9	Sandy Clay	103-57	5+800	1.8 R	0.6	14.3	34	16.0	18.0	CI	10	Low Plastic Clay
103-60	6+000	1.8 L	0.6	10.4	29	14.0	15.0	CL	7	Sandy Clay	103-59	6+000	1.8 R	0.6	10.3	27	13.0	14.0	CL	7	Sandy Clay
103-62	6+200	1.8 L	0.6	7.4	32	14.9	17.1	CI	10	Low Plastic Clay	103-61	6+200	1.8 R	0.6	11.0	31	15.3	15.7	CI	8	Sandy Clay
103-64	6+400	1.8 L	0.6	5.4	0	0.0	0.0	SP	0	Fine Sand	103-63	6+400	1.8 R	0.6	13.2	34	16.5	17.5	CI	9	Low Plastic Clay
103-66	6+600	1.8 L	0.6	14.3	37	17.0	20.0	CI	11	Low Plastic Clay	103-65	6+600	1.8 R	0.6	13.9	35	16.0	19.0	CI	10	Low Plastic Clay
	Mean			14.72	35.12	17.47	17.65		9.39						15.61	35.64	17.99	17.64		9.3	
	Standard Deviation			3.525	7.074	4.088	4.263		2.46						3.956	4.506	2.577	3.851		2.72	
	Statistical Difference @ 95% Confidence			NO	NO	NO	NO		NO						NO	NO	NO	NO		NO	
	Count			33	33	33	33		33						33	33	33	33		33	

File: Sask Low Pressure tire Study\#103 comparison Bias-MFC.xls

Table B-2; Soil Characteristics of Road 202

LOCATION		1.2 m LEFT OF CENTERLINE, (Low Pressure)							1.2 m RIGHT OF CENTERLINE, (High Pressure)						
		Soil Properties				One-Point Proctor Data			Soil Properties				One-Point Proctor Data		
Station	Depth(m)	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Wet Density (kg/cu m)	Dry Density (kg/cu m)	One-Point Moisture Content (%)	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Wet Density (kg/cu m)	Dry Density (kg/cu m)	One-Point Moisture Content (%)
0+200	0.3	13.5	33	16	17	2134	1849	15.4	12.4	33	18	15	2059	1801	14.3
0+200	0.6	15.9	35	17	18	2022	1734	16.6	16.4	32	12	20	2132	1847	15.4
0+200	1.0	15.1							15.3						
0+400	0.3	9.7	28	15	13	2157	1941	11.1	19.2	33	18	15	2059	1801	14.3
0+400	0.6	17.2	41	24	17	1884	1563	20.5	20.3	32	19	13	2048	1803	13.6
0+400	1.0	12.5							15.4						
0+600	0.3	13.0	35	17	18	2134	1849	15.4	14.0	33	18	15	2059	1801	14.3
0+600	0.6	16.0	37	17	20	2141	1863	14.9	23.2	38	22	16	1826	1551	17.7
0+600	1.0	22.9							26.5						
0+800	0.3	11.8	33	16	17	2134	1849	15.4	16.8	34	19	15	2059	1801	14.3
0+800	0.6	17.5	33	18	15	2054	1766	16.3	15.0	31	17	14	2048	1803	13.6
0+800	1.0	23.1							23.9						
1+000	0.3	13.4	29	16	13	2157	1941	11.1	14.5	29	16	13	2091	1864	12.2
1+000	0.6	18.7	26	15	11				14.5	33	17	16	2037	1776	14.7
1+000	1.0	18.0							22.0						
1+200	0.3	10.3	27	16	11	2195	1946	12.8	16.9	32	20	12	2059	1801	14.3
1+200	0.6	16.8	33	19	14	2054	1766	16.3	22.5	39	23	16	1826	1551	17.7
1+200	1.0	17.8							16.4						
1+400	0.3	11.9	30	18	12	2157	1941	11.1	13.9	29	16	13	2091	1864	12.2
1+400	0.6	9.6	28	15	13	2135	1901	12.3	11.4	27	16	11	2138	190+6	12.2
1+400	1.0	13.5							16.5						
1+600	0.3	11.7	33	17	16	1955	1680	16.4	11.4	25	16	9			
1+600	0.6	13.0	30	15	15	2135	1901	12.3	10.8	31	18	13	2048	1803	13.6
1+600	1.0	18.4							20.6						
1+800	0.3	10.3	31	15	16	2200	1954	12.6	11.4	31	14	17	2146	1861	15.3
1+800	0.6	13.3	30	15	15	2135	1901	12.3	13.0	28	14	14	2138	1906	12.2
1+800	1.0	17.3							27.8						
2+000	0.3	10.0	28	15	13	2157	1941	11.1	10.3	34	15	19	2147	1864	15.2
2+000	0.6	10.6	28	14	14	2135	1901	12.3	12.3	30	14	16	2152	1878	14.6
2+000	1.0	14.4							15.4						
2+200	0.3	12.0	34	15	19	2162	1885	14.7	13.9	31	13	18	2146	1861	15.3
2+200	0.6	11.7	31	15	16	2146	1896	13.2	14.1	31	14	17	2152	1878	14.6
2+200	1.0	17.4							19.2						
2+400	0.3	10.2	33	14	19	2162	1882	14.9	10.9	35	15	20	2106	1795	17.3
2+400	0.6	6.0	32	14	18	2156	1881	14.6	12.4	32	15	17	2152	1878	14.6
2+400	1.0	16.2							15.5						
2+600	0.3	11.1	33	26	7				11.3	34	14	20	2106	1795	17.3
2+600	0.6	12.1	34	14	20	2141	1863	14.9	14.1	29	16	13	2138	1906	12.2
2+600	1.0	10.3							13.9						
2+800	0.3	10.4	33	15	18	2162	1882	14.9	11.1	36	14	22	2106	1795	17.3
2+800	0.6	11.3	31	14	17	2156	1881	14.6	9.9	33	15	18	2132	1847	15.4
2+800	1.0	17.2							16.7						
3+000	0.3	11.4	32	16	16	2134	1849	15.4	12.3	38	15	23	2106	1795	17.3
3+000	0.6	10.6	31	16	15	2146	1896	13.2	18.7	34	24	10			
3+000	1.0	27.2							22.5						
3+200	0.3	11.1	31	15	16	2200	1954	12.6	11.4	33	14	19	2146	1861	15.3
3+200	0.6	15.2	31	14	17	2156	1881	14.6	12.1	32	15	17	2152	1878	14.6
3+200	1.0	17.8							31.1						
3+400	0.3	11.2	34	14	20	2162	1885	14.7	12.2	34	15	19	2147	1864	15.2
3+400	0.6	11.1	33	15	18	2141	1863	14.9	15.3	34	14	20	2132	1847	15.4
3+400	1.0	18.0							17.4						
3+600	0.3	11.3	33	15	18	2162	1882	14.9	12.2	31	15	16	2142	1891	13.3
3+600	0.6	11.2	31	16	15	2146	1896	13.2	12.0	30	15	15	2152	1878	14.6
3+600	1.0	18.5							18.1						
3+800	0.3	9.6	32	14	18	2162	1882	14.9	11.0	34	14	20	2146	1861	15.3
3+800	0.6	16.8	34	16	18	2022	1734	16.6	13.3	32	14	18	2132	1847	15.4
3+800	1.0	20.4							22.4						
4+000	0.3	12.6	35	15	20	2162	1885	14.7	11.8	33	16	17	2147	1864	15.2
4+000	0.6	15.2	33	16	17	2146	1896	13.2	13.7	35	16	19	2132	1847	15.4
4+000	1.0	18.8							22.8						
4+200	0.3	11.0	31	15	16	2200	1954	12.6	11.6	31	16	15	2091	1864	12.2
4+200	0.6	16.2	33	15	18	2156	1881	14.6	19.9	46	16	30			
4+200	1.0	17.8							29.7						
4+400	0.3	11.8	34	15	19	2162	1885	14.7	11.0	29	15	14	2210	1979	11.7
4+400	0.6	13.1	33	15	18	2156	1881	14.6	16.1	35	17	18	2037	1776	14.7
4+400	1.0	17.3							13.8						
4+600	0.3	9.7	26	15	11	2195	1946	12.8	11.8	32	14	18	2146	1861	15.3

Table B-2; Soil Characteristics of Road 202

LOCATION		1.2 m LEFT OF CENTERLINE, (Low Pressure)							1.2 m RIGHT OF CENTERLINE, (High Pressure)						
		Soil Properties				One-Point Proctor Data			Soil Properties				One-Point Proctor Data		
Station	Depth(m)	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Wet Density (kg/cu m)	Dry Density (kg/cu m)	One-Point Moisture Content (%)	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Wet Density (kg/cu m)	Dry Density (kg/cu m)	One-Point Moisture Content (%)
4+600	0.6	13.6	35	16	19	2141	1863	14.9	16.5	34	17	17	2037	1776	14.7
4+600	1.0	16.5							20.8						
4+800	0.3	12.9	35	17	18	2134	1849	15.4	11.8	28	14	14	2210	1979	11.7
4+800	0.6	13.0	32	18	14	2054	1766	16.3	22.3	41	25	16	1826	1551	17.7
4+800	1.0	16.1							20.9						
5+000	0.3	10.7	34	15	19	2162	1885	14.7	11.2	29	15	14	2210	1979	11.7
5+000	0.6	15.1	40	20	20	2022	1734	16.6	19.0	43	26	17	1826	1551	17.7
5+000	1.0	18.4							14.3						
5+200	0.3	13.8	36	18	18	1955	1680	16.4	11.8	30	15	15	2142	1891	13.3
5+200	0.6	19.6	40	22	18	2022	1734	16.6	12.4	41	22	19	1826	1551	17.7
5+200	1.0	16.4							9.5						
5+400	0.3	13.1	28	16	12	2157	1941	11.1	12.0	32	17	15	2091	1864	12.2
5+400	0.6	18.0	39	22	17	1884	1563	20.5	12.4	33	17	16	2048	1803	13.6
5+400	1.0	23.4							20.8						
5+600	0.3	14.1	34	16	18	2162	1882	14.9	8.5	26	14	12	2210	1979	11.7
5+600	0.6	16.3	38	17	21	2141	1863	14.9	14.8	29	16	13	2138	1906	12.2
5+600	1.0	14.1							15.1						
5+800	0.3	10.9	26	15	11	2195	1946	12.8	12.9	30	15	15	2142	1891	13.3
5+800	0.6	11.4	31	15	16	2146	1896	13.2	11.5	26	17	9			
5+800	1.0	12.2							19.6						
6+000	0.3	10.4	28	14	14	2200	1954	12.6	13.0	36	18	18	2147	1864	15.2
6+000	0.6	12.6	30	16	14	2135	1901	12.3	10.9						
6+000	1.0	18.2							14.7						
6+200	0.3	11.8	28	15	13				11.6	31	15	16	2142	1891	13.3
6+200	0.6	8.0	31	17	14	2135	1901	12.3	9.6	32	15	17	2152	1878	14.6
6+200	1.0	20.5							25.3						
6+400	0.3	9.2	25	15	10	2195	1946	12.8	19.3	34	20	14	2059	1801	14.3
6+400	0.6	15.0	34	19	15	2054	1766	16.3	18.5	35	19	16	2037	1776	14.7
6+400	1.0	8.4							10.7						
6+600	0.3	12.3	36	20	16	1955	1680	16.4	11.6	31	17	14	2091	1864	12.2
6+600	0.6	16.8	38	22	16	1884	1563	20.5	16.4	32	19	13	2048	1803	13.6
6+600	1.0	17.5							28.3						
6+800	0.3	13.3	35	20	15	1955	1680	16.4	13.5	30	15	15	2142	1891	13.3
6+800	0.6	20.5	39	22	17	1884	1563	20.5	18.0	32	28	4			
6+800	1.0	18.1													
7+000	0.3	11.8	30	15	15	2200	1954	12.6	10.6	30	15	15	2210	1979	11.7
7+000	0.6	26.9	37	19	18	2022	1734	16.6	18.9	37	19	18	2037	1776	14.7
7+000	1.0	22.8							24.6						
7+200	0.3	21.6	40	22	18	1955	1680	16.4	19.7	38	21	17			
7+200	0.6	25.6	38	23	15	1884	1563	20.5	20.0	39	25	14	1826	1551	17.7
7+200	1.0	25.5							26.2						
7+400	0.6	18.0	35	19	16	2054	1766	16.3	14.8	36	15	21	2106	1795	17.3
7+400	1.0	24.3							11.1	28	15	13	2138	1906	12.2
7+600	0.3	13.8	33	16	17				26.2						
7+600	0.3	12.2	27	15	12	2157	1941	11.1	13.8	35	16	19	2147	1864	15.2
7+600	0.6	5.7	21	16	5				7.6	18	16	2			
7+600	1.0	14.3							19.1						
7+800	0.3	8.2	26	13	13	2200	1954	12.6	6.1	23	14	9			
7+800	0.6	10.5	27	21	6				14.0	27	22	5			
7+800	1.0	16.6							8.4						
8+000	0.3	8.6	27	16	11	2195	1946	12.8	10.6	30	18	12			
8+000	0.6	10.9	29	16	13				11.1	29	16	13			
8+000	1.0	9.9							12.6						
No. of Observations		120	70	70	70	64	64	64	119	70	70	70	64	64	64
Mean		14.6	32.2	16.5	15.7	2113.0	1845.4	14.6	15.6	32.3	16.7	15.6	2090.4	1827.2	14.5
Standard Deviatio		4.4	3.9	2.5	3.2	85.7	104.9	2.3	5.1	4.0	3.1	3.5	97.7	103.3	1.8
STATISTICAL DIFFERENCE AT THE 95% CONFIDENCE		No	No	No	N0	No	No	No	No	No	No	N0	No	No	No

Table B-3, Pre-Experiment Dynamic Cone Penetration Tests on Road 103, Northbound, (Low Pressure), & Southbound, (High Pressure), North & South of Road 105,

	NBL, (Low Pressure) Test Road 103			SBL, (High Pressure), Test Road 103			Comparison of DCP between Lanes
Depth mm	N = 25 Avg mm/bl	Std Dev mm/bl	CV	N = 25 Avg mm/bl	Std Dev mm/bl	CV	Difference in Penetration mm/blow
25	6	2	0.40	6	3	0.40	0
50	7	3	0.35	7	4	0.47	0
75	10	4	0.40	10	5	0.46	0
100	14	4	0.26	13	5	0.40	0
125	17	5	0.31	17	6	0.33	0
150	19	6	0.33	17	6	0.36	2
175	21	6	0.30	20	5	0.24	1
200	22	8	0.39	22	6	0.30	0
225	20	7	0.36	22	7	0.33	-2
250	22	7	0.31	22	6	0.26	-1
275	21	6	0.29	21	6	0.28	0
300	21	6	0.29	20	6	0.31	1
325	22	6	0.29	21	6	0.30	1
350	20	7	0.33	20	7	0.35	0
375	23	10	0.43	21	7	0.35	2
400	23	11	0.47	23	7	0.30	1
450	21	7	0.35	21	6	0.29	-1
500	22	5	0.24	22	7	0.33	0
550	25	8	0.33	24	9	0.38	0
600	24	9	0.36	24	9	0.37	1
650	24	8	0.34	21	7	0.34	3
700	25	10	0.41	24	9	0.38	1
750	24	12	0.50	24	8	0.33	0
800	23	10	0.46	27	9	0.35	-4
850	23	10	0.43	28	10	0.35	-5
900	23	8	0.34	26	12	0.45	-3
950	26	11	0.43	26	10	0.39	0
1000	24	10	0.43	24	11	0.44	0

Table B-4, Pre-Trial Dynamic Cone Penetration along Test Route 202 including 1.6 km South of Road 206

Depth, mm	NBL, S of Road 206			SBL, S of Road 206			NBL, Test Road 202			SBL, Test Road 202		
	High Pressure			Low Pressure			High Pressure			Low Pressure		
	N = 8 Avg mm/bl	Std Dev mm/bl	CV	N = 8 Avg mm/bl	Std Dev mm/bl	CV	N = 32 Avg mm/bl	Std Dev mm/bl	CV	N = 32 Avg mm/bl	Std Dev mm/bl	CV
25	7	3	0.37	5	2	0.44	8	4	0.49	6	5	0.81
50	8	2	0.26	7	6	0.88	9	7	0.75	6	3	0.44
75	10	2	0.21	6	3	0.56	12	6	0.49	8	3	0.40
100	11	4	0.34	9	3	0.34	13	5	0.36	9	3	0.30
125	15	4	0.23	11	3	0.29	15	5	0.35	11	4	0.36
150	19	3	0.17	12	3	0.23	19	7	0.35	13	5	0.36
175	23	4	0.16	12	4	0.33	18	7	0.37	15	5	0.31
200	25	7	0.27	13	4	0.34	19	7	0.35	17	6	0.35
225	27	6	0.22	18	5	0.29	21	8	0.39	17	5	0.32
250	24	11	0.46	18	5	0.28	20	9	0.43	16	6	0.36
275	30	11	0.38	19	7	0.36	21	8	0.41	18	5	0.30
300	31	13	0.42	18	7	0.41	22	8	0.38	19	8	0.41
325	34	15	0.43	18	8	0.44	22	9	0.42	19	8	0.41
350	35	16	0.46	22	6	0.30	23	10	0.45	19	8	0.43
375	36	15	0.41	23	7	0.29	24	11	0.47	19	9	0.48
400	35	16	0.46	25	12	0.46	23	12	0.53	20	11	0.54
450	38	19	0.50	27	10	0.39	23	13	0.57	18	11	0.59
500	37	21	0.57	25	14	0.53	22	11	0.52	19	9	0.46
550	40	18	0.46	32	23	0.70	23	11	0.48	18	9	0.49
600	39	13	0.34	25	15	0.61	25	12	0.47	20	10	0.51
650	38	10	0.26	32	15	0.47	24	10	0.43	20	8	0.41
700	32	12	0.39	30	15	0.51	23	10	0.44	20	9	0.45
750	37	12	0.32	23	18	0.79	23	11	0.47	19	8	0.43
800	39	9	0.24	19	14	0.71	25	16	0.64	20	10	0.51
850	39	13	0.34	24	14	0.61	26	14	0.55	21	9	0.45
900	40	16	0.41	27	24	0.87	26	18	0.69	22	10	0.44
950	36	10	0.28	24	17	0.71	25	10	0.41	23	11	0.48
1000	34	11	0.32	20	14	0.71	26	12	0.45	20	9	0.44

File: Table 3-5, DCP along Test Route 202 - Merv

Table B-5; Pre-Trial Summary of Dynamic Cone Penetration Test Data , Grid Road 601

	NBL, Test Loop - LP			SBL, Test Loop - HP			NBL, S of Test Loop			SBL, S of Test Loop		
Depth mm	N = 4 Avg mm/bl	Std Dev mm/bl	CV	N = 5 Avg mm/bl	Std Dev mm/bl	CV	N = 7 Avg mm/bl	Std Dev mm/bl	CV	N = Avg mm/b	Std Dev mm/bl	CV
25	5	1	0.11	7	3	0.39	6	2	0.43	4	1	0.32
50	4	1	0.23	7	3	0.43	5	2	0.48	6	2	0.31
75	6	3	0.42	8	2	0.22	6	2	0.43	7	3	0.36
100	8	2	0.28	10	3	0.33	7	2	0.30	8	2	0.30
125	8	2	0.29	11	4	0.36	10	4	0.36	9	3	0.39
150	11	1	0.10	10	3	0.31	10	3	0.25	10	3	0.36
175	12	4	0.33	10	4	0.41	12	2	0.20	11	6	0.54
200	13	6	0.48	12	7	0.61	14	4	0.28	8	2	0.30
225	13	7	0.51	14	9	0.60	19	6	0.33	11	5	0.44
250	13	7	0.52	15	5	0.33	18	3	0.18	13	5	0.37
275	15	7	0.46	18	6	0.32	18	7	0.39	14	5	0.34
300	15	9	0.63	20	5	0.23	23	3	0.12	18	7	0.41
325	17	10	0.57	17	5	0.32	18	9	0.48	18	7	0.38
350	15	8	0.52	15	6	0.40	15	10	0.70	20	6	0.32
375	16	7	0.46	16	9	0.55	18	12	0.64	18	7	0.39
400	12	7	0.56	16	4	0.27	17	12	0.73	26	18	0.69
450	12	6	0.48	14	8	0.60	21	10	0.49	22	17	0.75
500	20	4	0.19	12	5	0.39	21	10	0.50	16	9	0.58
550	20	1	0.05	14	4	0.30	16	9	0.58	15	6	0.42
600	16	10	0.64	15	4	0.23	17	11	0.64	13	6	0.48
650	21	15	0.73	13	5	0.42	15	8	0.57	13	5	0.42
700	17	11	0.64	13	7	0.56	17	8	0.46	12	6	0.48
750	17	13	0.75	16	12	0.74	17	10	0.57	13	5	0.38
800	17	7	0.43	11	6	0.56	16	8	0.51	13	3	0.27
850	14	8	0.59	16	7	0.44	15	7	0.46	14	6	0.41
900	15	9	0.62	15	8	0.51	14	6	0.41	16	6	0.40
950	19	9	0.46	19	12	0.62	12	5	0.45	14	5	0.37
1000	16	9	0.55	18	12	0.66	14	7	0.50	13	7	0.52

Table 3-14; Pre-Experiment DCP Test Data , Grid Road #601-merv

Table B-6 Post-Trial Summary of DCP Test Data Test Road 103

	NBL, S of Road 105			SBL, S of Road 105			NBL, Test Road 103			SBL, Test Road 103		
Depth mm	N = 8 Avg mm/bl	Std Dev mm/bl	CV	N = 8 Avg mm/bl	Std Dev mm/bl	CV	N = 25 Avg mm/bl	Std Dev mm/bl	CV	N = 25 Avg mm/bl	Std Dev mm/bl	CV
25	6	2	0.37	5	1	0.20	6	2	0.40	6	3	0.40
50	9	1	0.15	9	3	0.32	7	3	0.35	7	4	0.47
75	12	4	0.34	10	3	0.27	10	4	0.40	10	5	0.46
100	15	3	0.21	12	2	0.17	14	4	0.26	13	5	0.40
125	19	3	0.15	15	4	0.27	17	5	0.31	17	6	0.33
150	19	6	0.30	15	5	0.34	19	6	0.33	17	6	0.36
175	20	6	0.29	19	7	0.39	21	6	0.30	20	5	0.24
200	24	7	0.27	23	8	0.33	22	8	0.39	22	6	0.30
225	24	7	0.29	21	4	0.21	20	7	0.36	22	7	0.33
250	26	9	0.33	24	7	0.29	22	7	0.31	22	6	0.26
275	25	9	0.38	23	7	0.32	21	6	0.29	21	6	0.28
300	21	9	0.42	23	6	0.24	21	6	0.29	20	6	0.31
325	28	10	0.34	25	9	0.34	22	6	0.29	21	6	0.30
350	29	6	0.21	24	9	0.39	20	7	0.33	20	7	0.35
375	28	8	0.30	25	11	0.44	23	10	0.43	21	7	0.35
400	24	10	0.42	26	9	0.33	23	11	0.47	23	7	0.30
450	28	13	0.46	28	9	0.33	21	7	0.35	21	6	0.29
500	33	12	0.36	25	10	0.39	22	5	0.24	22	7	0.33
550	34	14	0.43	28	10	0.38	25	8	0.33	24	9	0.38
600	32	18	0.55	33	13	0.39	24	9	0.36	24	9	0.37
650	30	14	0.48	32	12	0.37	24	8	0.34	21	7	0.34
700	39	18	0.47	30	12	0.41	25	10	0.41	24	9	0.38
750	40	19	0.46	33	18	0.53	24	12	0.50	24	8	0.33
800	37	26	0.69	34	19	0.55	23	10	0.46	27	9	0.35
850	28	20	0.71	33	22	0.67	23	10	0.43	28	10	0.35
900	31	18	0.58	37	17	0.45	23	8	0.34	26	12	0.45
950	30	20	0.66	38	17	0.44	26	11	0.43	26	10	0.39
1000	33	21	0.65	36	13	0.35	24	10	0.43	24	11	0.44

Table B-7 Post Trial DCP Measurement Summary

Depth mm	NBL, S of Road 206 N = 3 Avg mm/bl	Std Dev mm/bl	CV	SBL, S of Road 206 N = 3 Avg mm/bl	Std Dev mm/bl	CV	NBL, Test Road 202 N=24 Avg mm/bl	Std Dev mm/bl	CV	SBL, Test Road 202 N = 30 Avg mm/bl	Std Dev mm/bl	CV
25	17	7	0.44	12	1	0.05	6	3	0.57	6	2	0.34
50	12	1	0.08	8	3	0.33	8	3	0.41	7	2	0.28
75	12	4	0.34	8	4	0.45	11	4	0.37	9	3	0.32
100	19	2	0.11	9	4	0.48	14	5	0.34	12	3	0.27
125	18	2	0.11	11	7	0.62	17	6	0.36	16	5	0.35
150	22	3	0.11	11	3	0.28	20	8	0.40	18	7	0.39
175	23	4	0.17	15	4	0.28	19	6	0.29	20	7	0.36
200	26	4	0.14	16	5	0.31	22	6	0.27	22	7	0.33
225	26	4	0.16	17	5	0.27	21	7	0.32	24	7	0.28
250	26	4	0.16	18	2	0.08	23	7	0.32	24	7	0.28
275	30	8	0.25	20	3	0.12	23	6	0.25	22	7	0.31
300	30	13	0.42	24	2	0.09	22	7	0.30	23	7	0.32
325	35	12	0.34	30	3	0.10	23	6	0.24	23	8	0.36
350	38	9	0.22	31	3	0.11	24	7	0.30	25	8	0.32
375	46	12	0.25	31	2	0.07	22	9	0.41	24	10	0.41
400	46	12	0.25	39	6	0.15	22	9	0.43	26	10	0.40
450	48	9	0.19	36	2	0.04	26	12	0.45	23	9	0.40
500	48	4	0.08	43	13	0.30	26	11	0.44	23	7	0.30
550	41	14	0.36	43	19	0.44	26	11	0.44	24	9	0.36
600	45	21	0.46	38	15	0.39	26	11	0.43	23	8	0.35
650	41	27	0.65	38	18	0.46	27	11	0.40	25	9	0.37
700	41	25	0.63	34	13	0.38	26	12	0.47	27	9	0.34
750	28	5	0.17	22	10	0.43	29	12	0.41	28	14	0.52
800	32	3	0.09	30	12	0.39	28	12	0.44	29	14	0.46
850	41	8	0.20	24	16	0.67	30	12	0.38	31	13	0.43
900	40	6	0.16	34	30	0.91	34	13	0.39	32	12	0.39
950	32	13	0.40	34	11	0.32	32	13	0.40	31	15	0.49
1000	37	15	0.40	28	1	0.03	34	13	0.39	33	16	0.48

APPENDIX C

FIGURES

Figure C-1
Test Road 103, Station 2+198 NBL

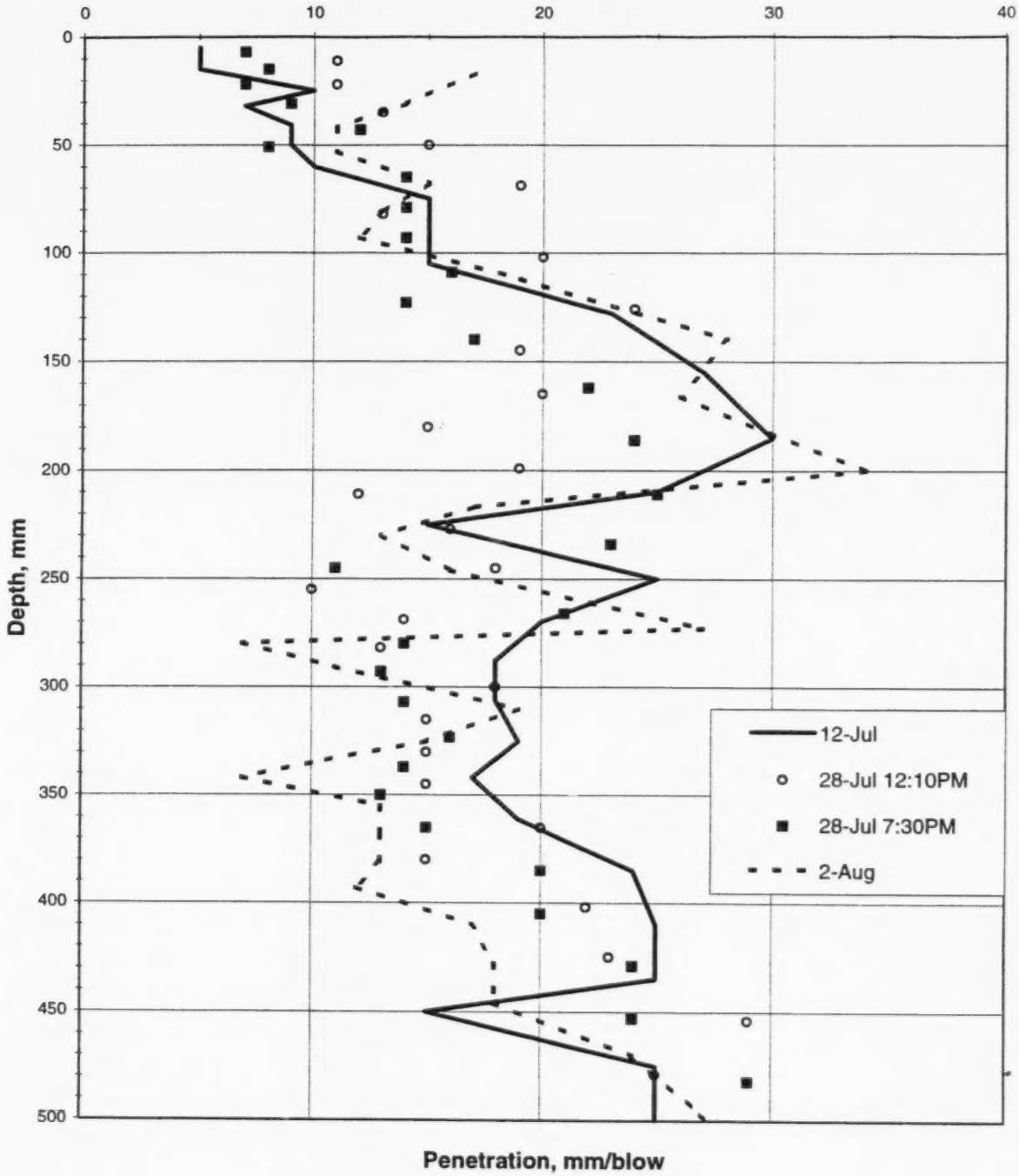

Figure C-2
Test Road 103, Station 2+198 SBL

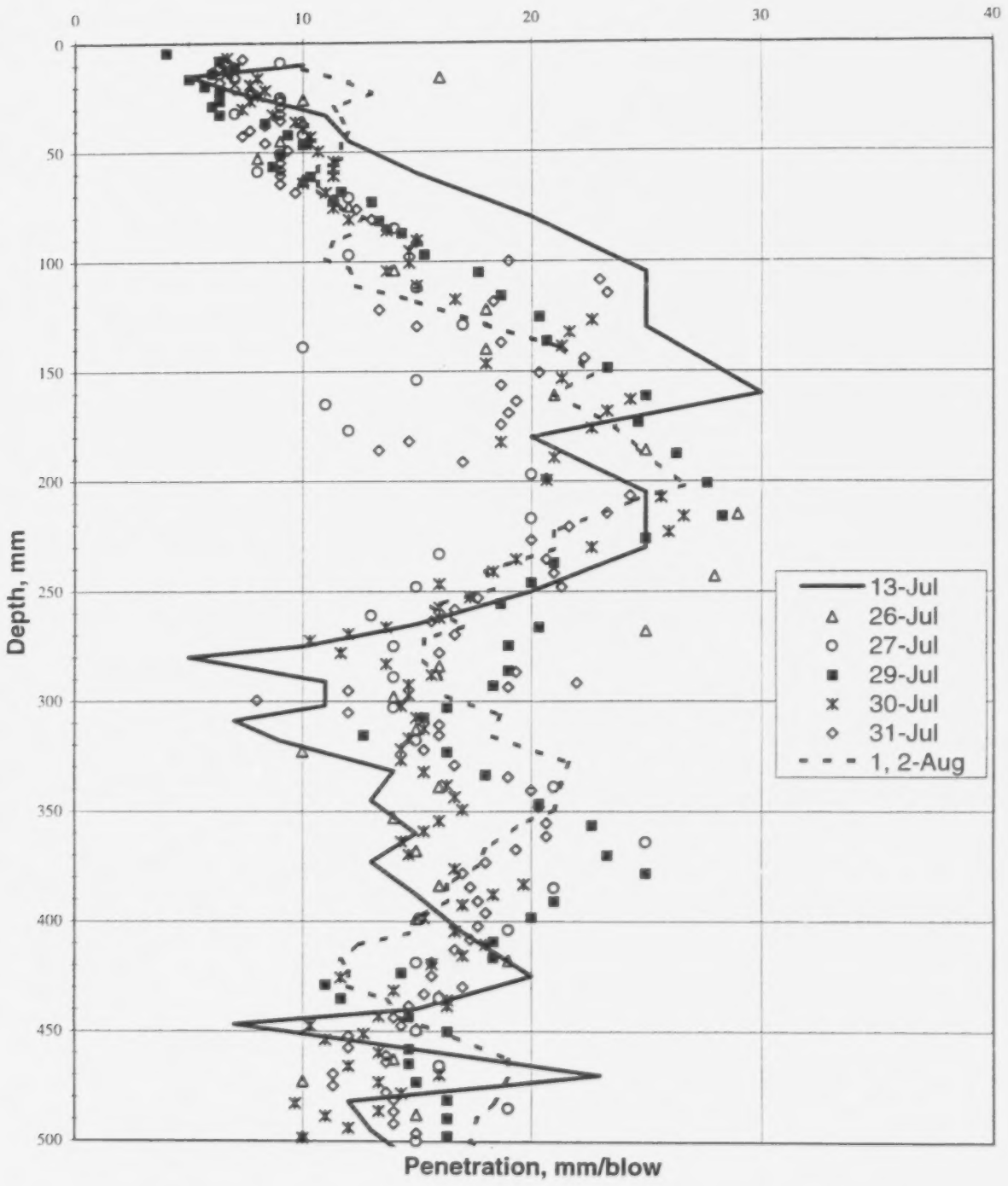

Figure C-3
Test Road 103, Station 3+398 NBL

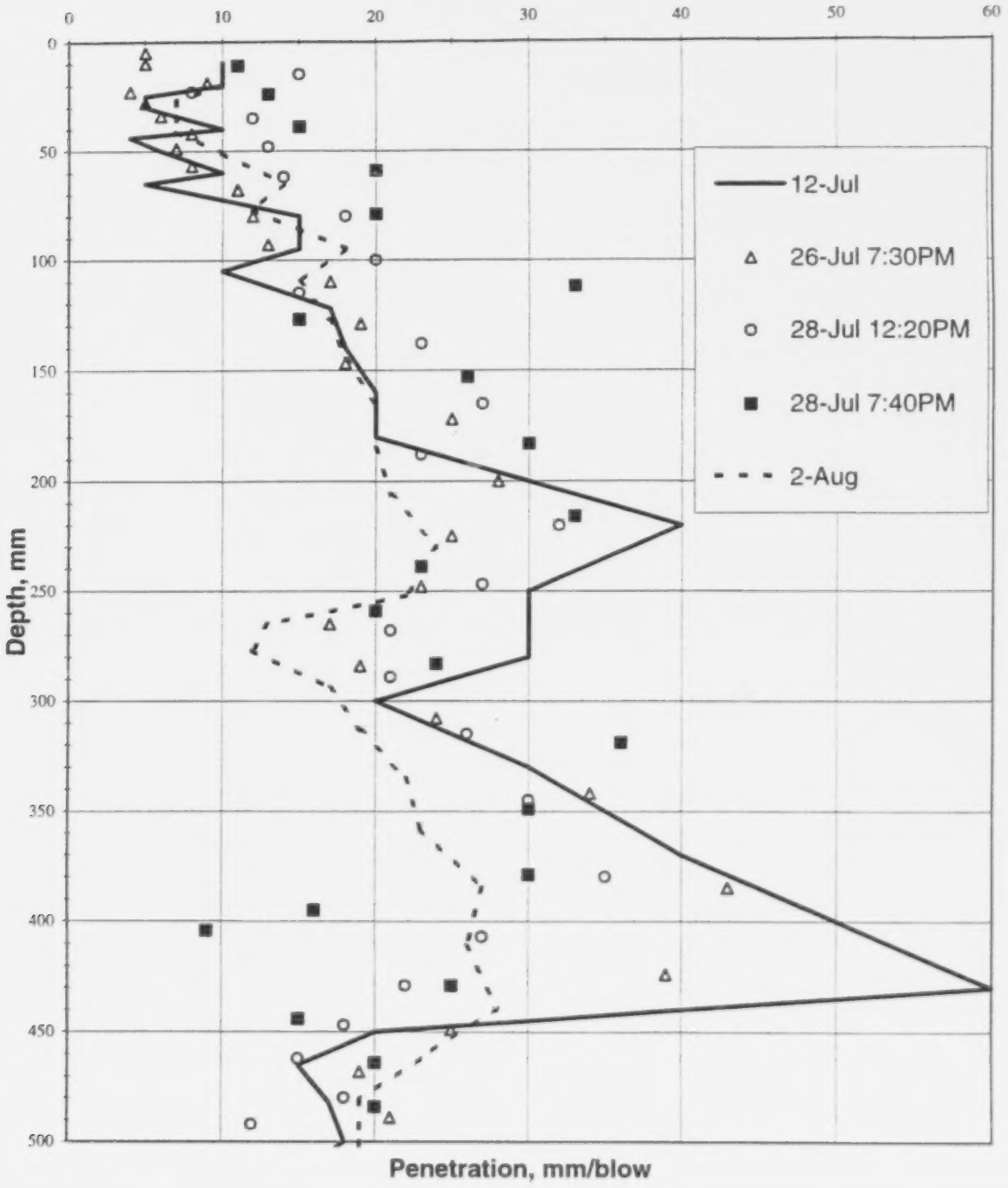

Figure C-4
Test Road 103, Station 3+398 SBL

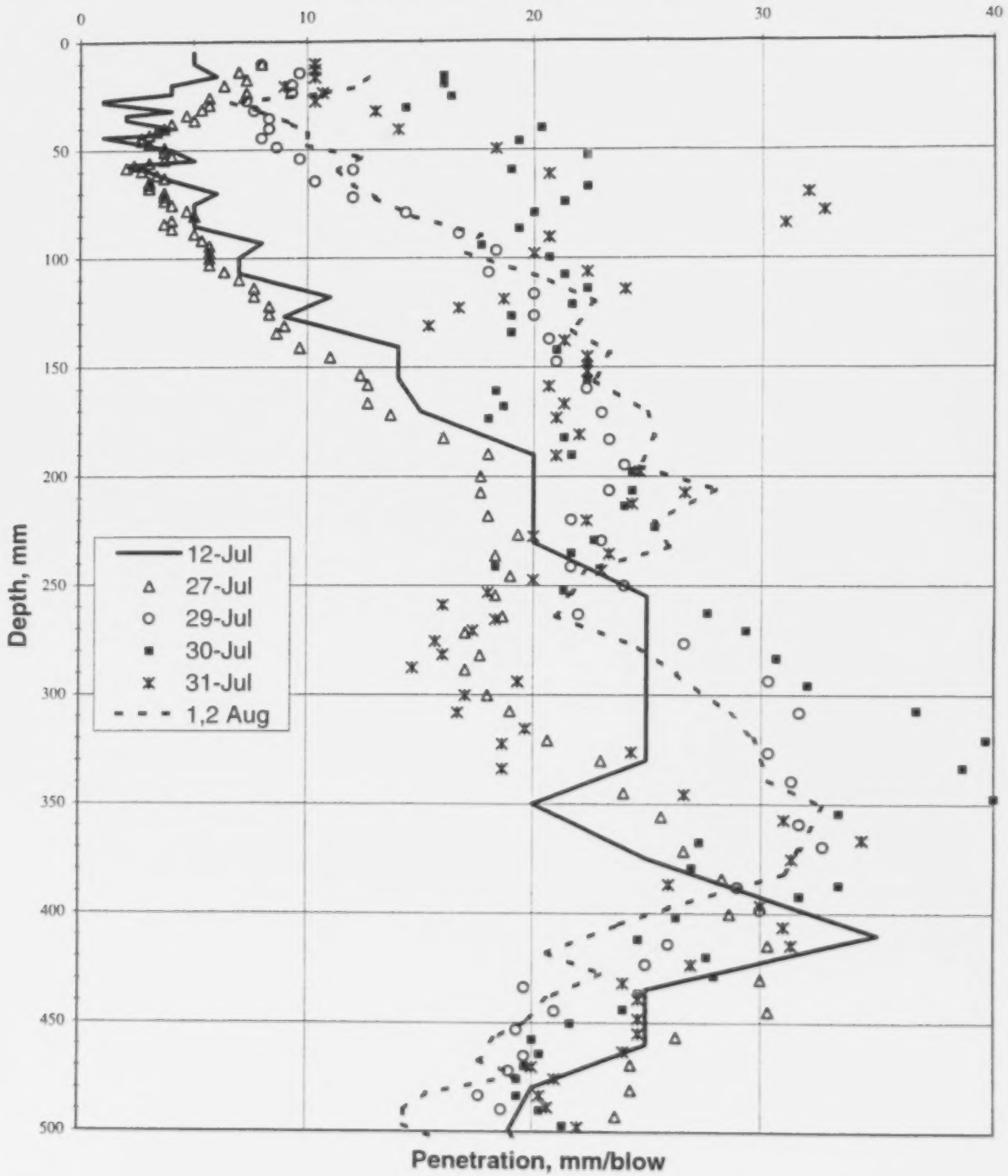

Figure C-5
Test Road 103, Station 3+598 NBL

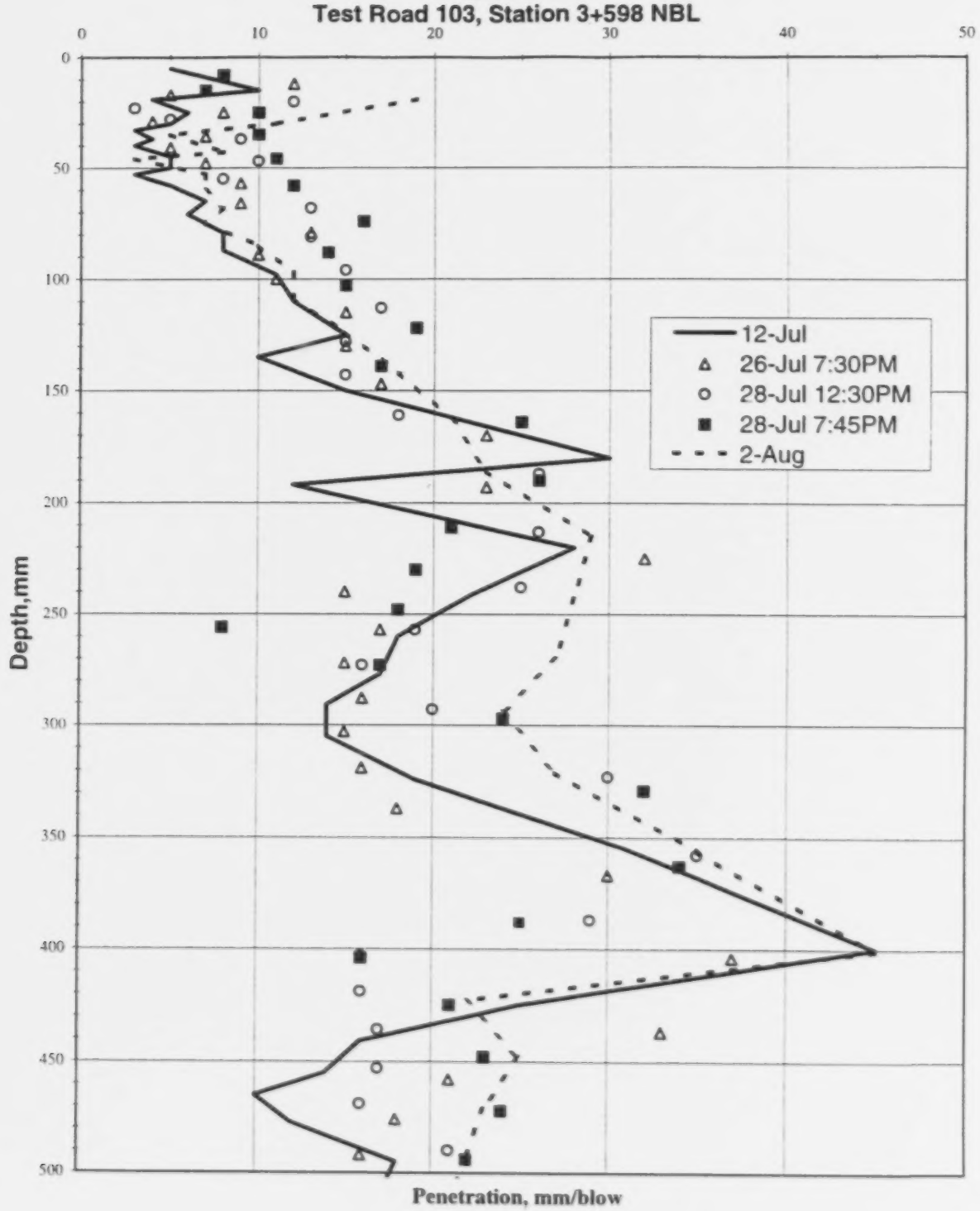

Figure C-6
Test Road 103, Station 3+598 SBL

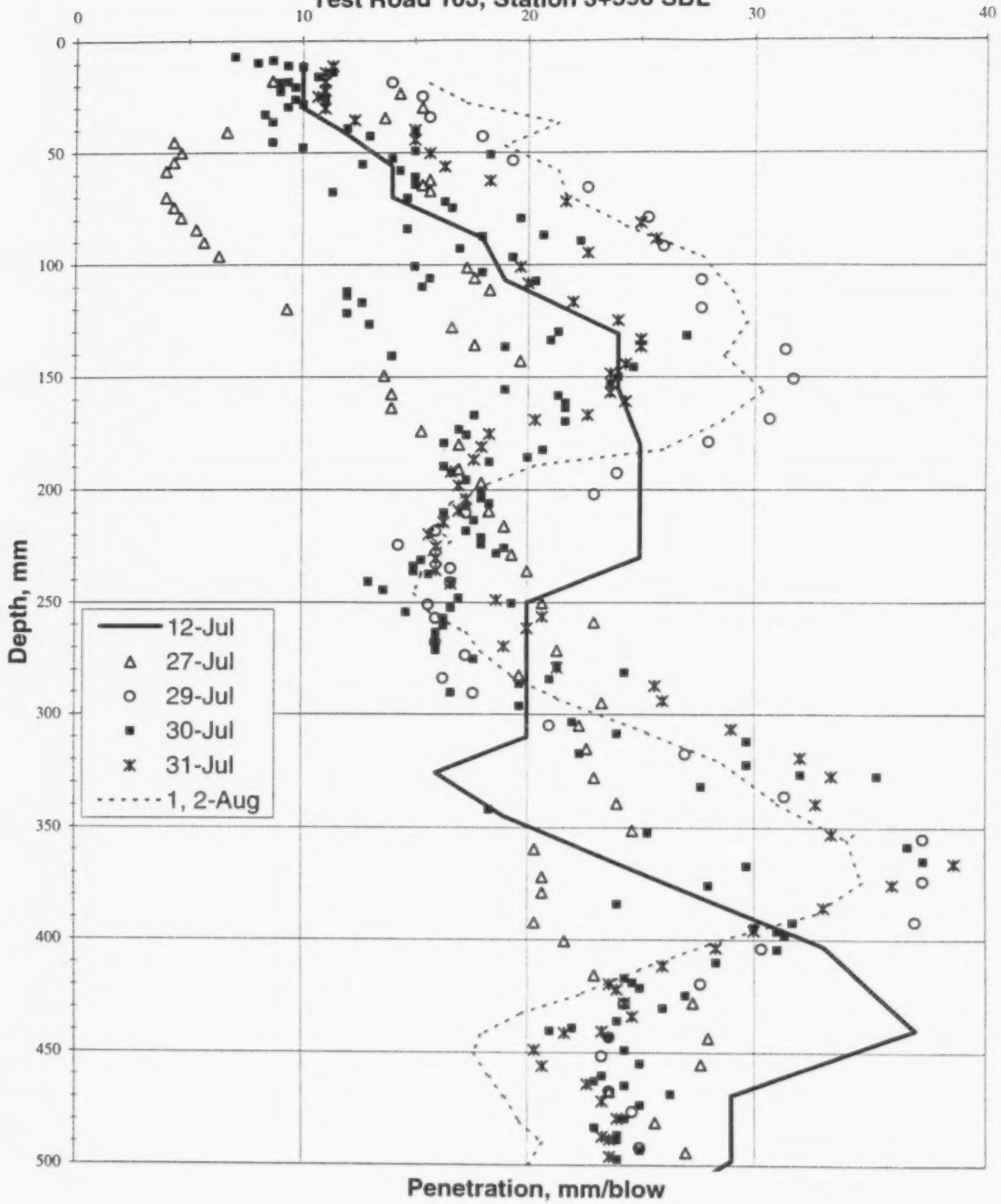

Figure C-7
Test Road 103, Station 3+798 NBL

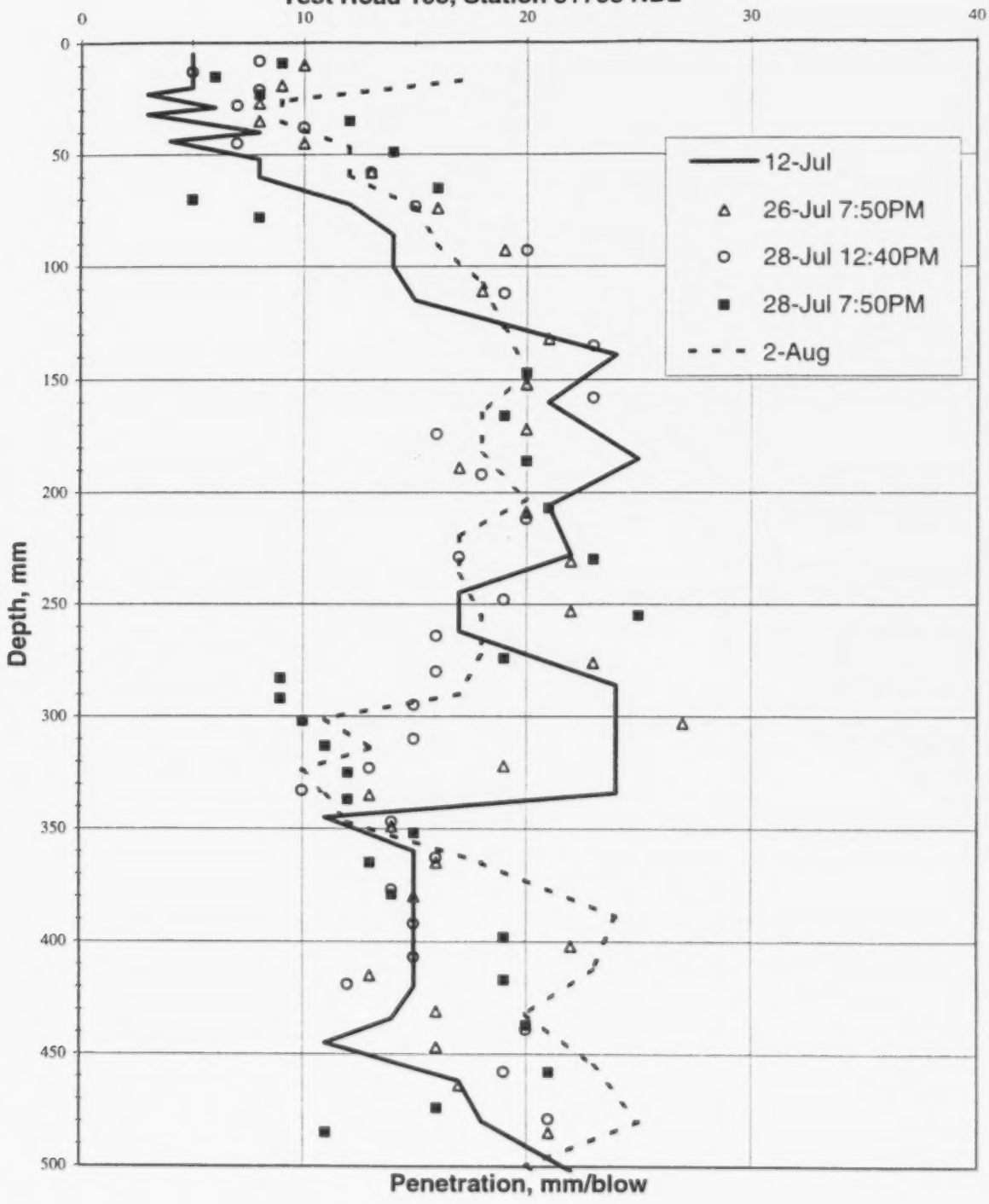

Figure C-8
Test Road 103, Station 3+798 SBL

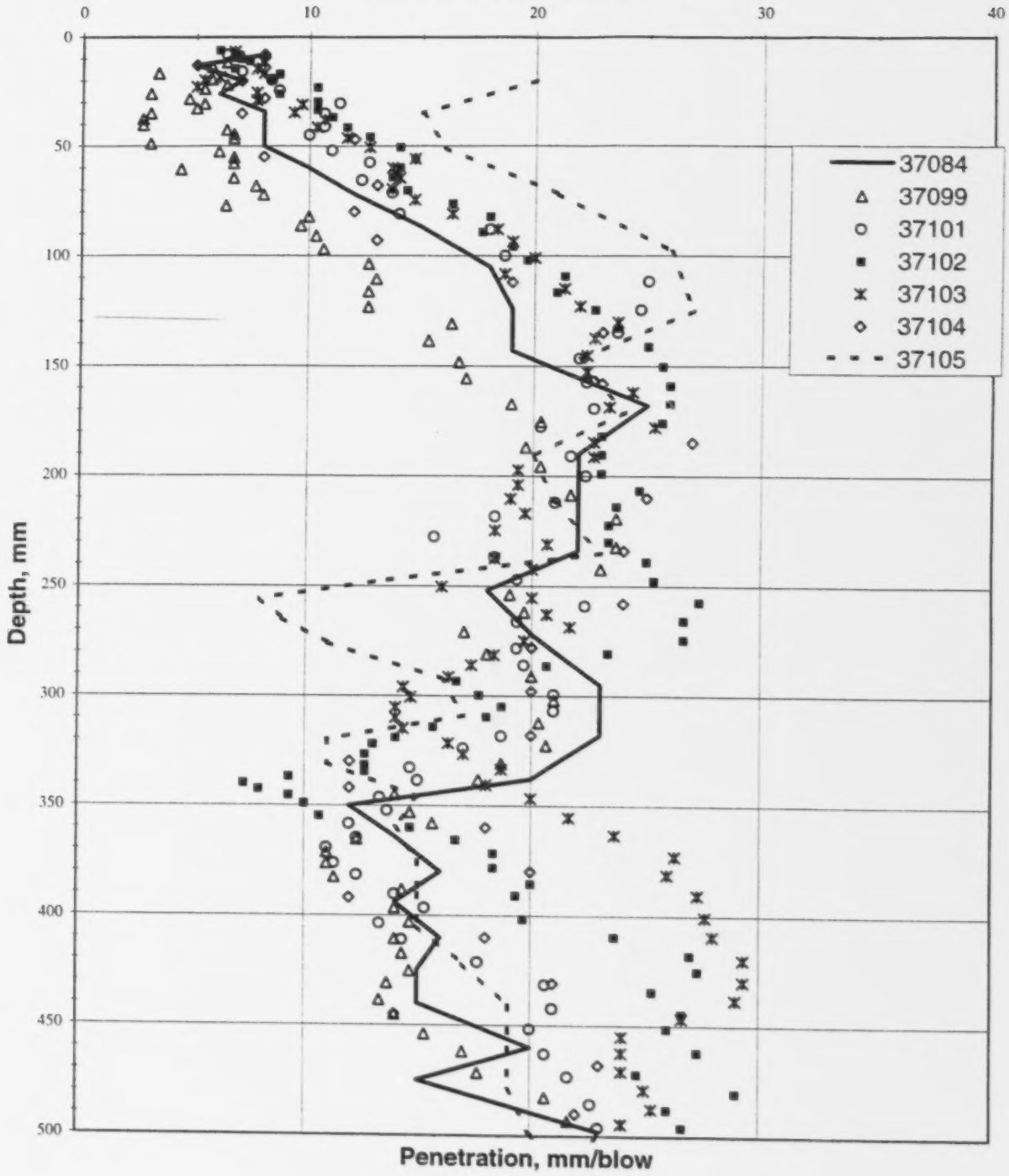

Figure C-9
Test Road 103, Station 5+598 NBL

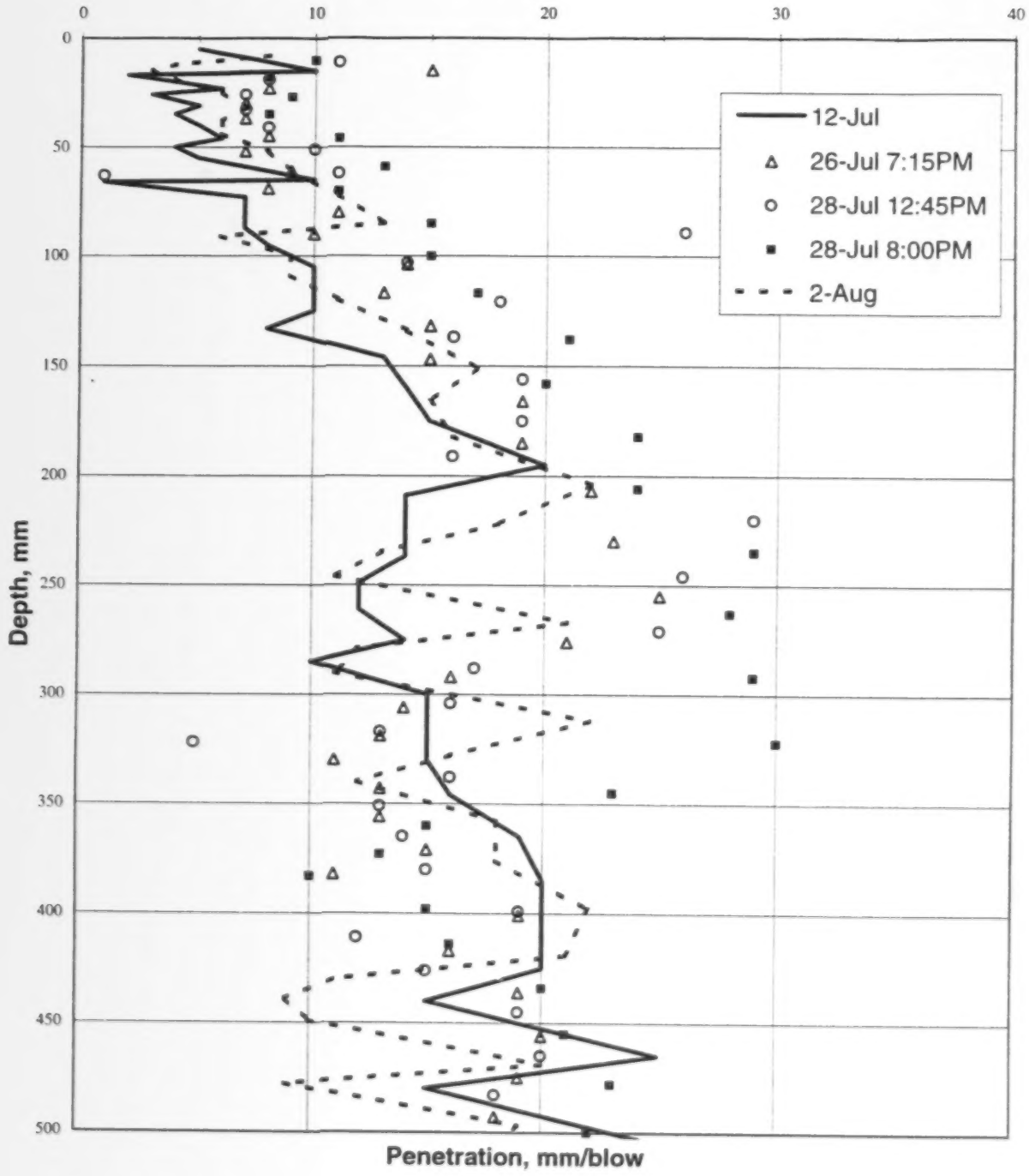

Figure C-10
Test Road 103, Station 5+998 SBL

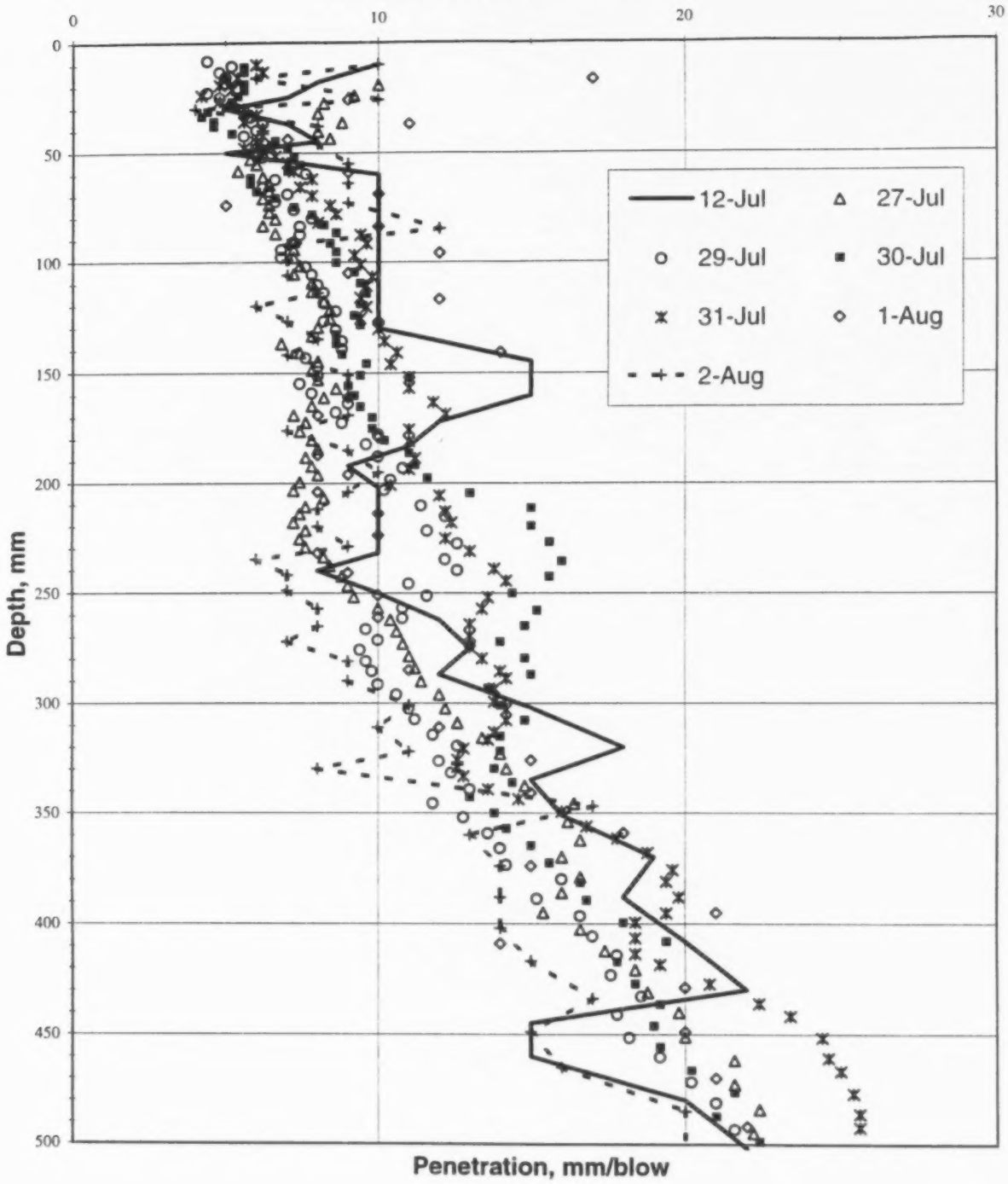

Figure C-11
Test Road 202, Station 2+200 NBL

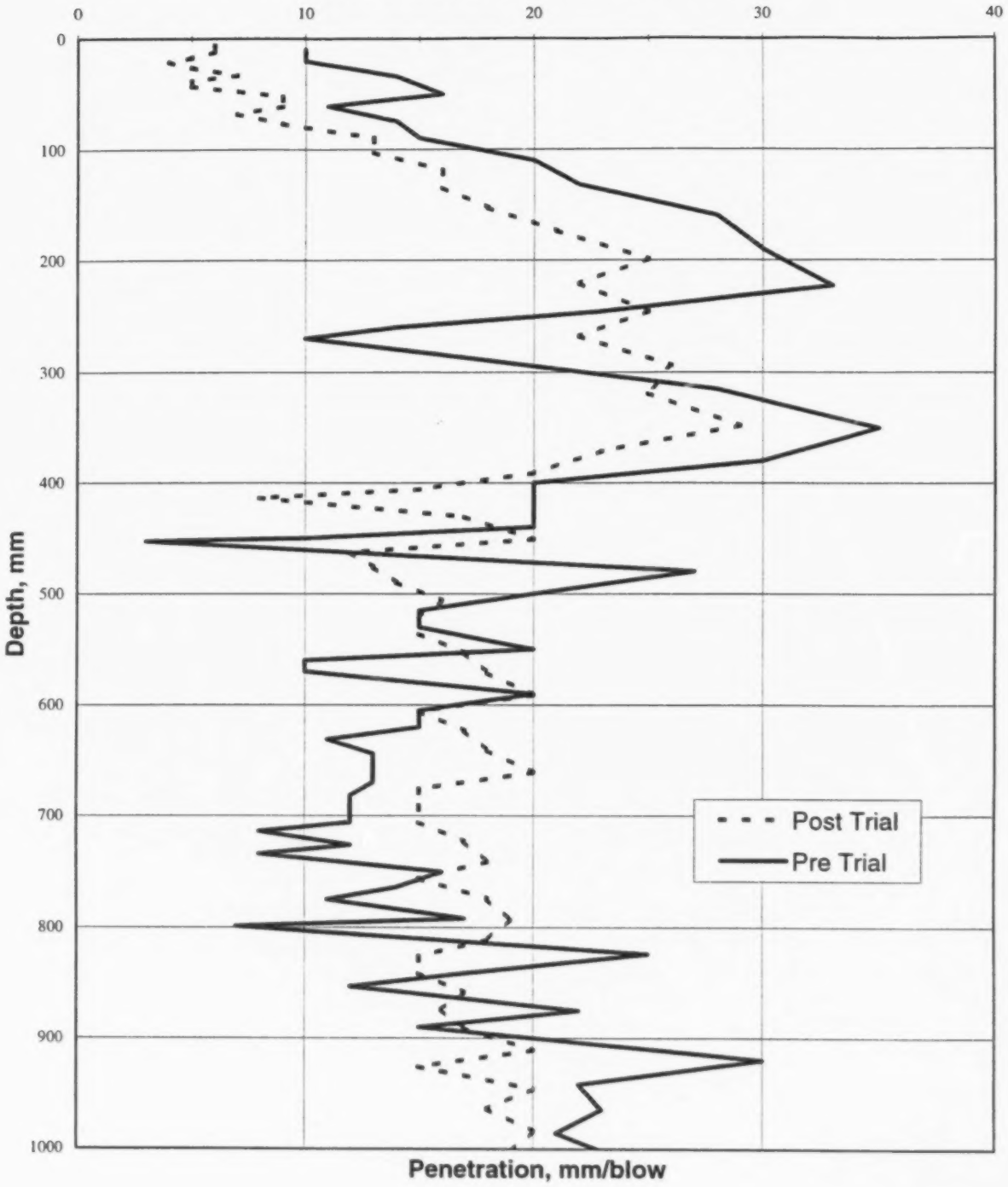

Figure C-12
Test Road 202, Station 2+200 SBL

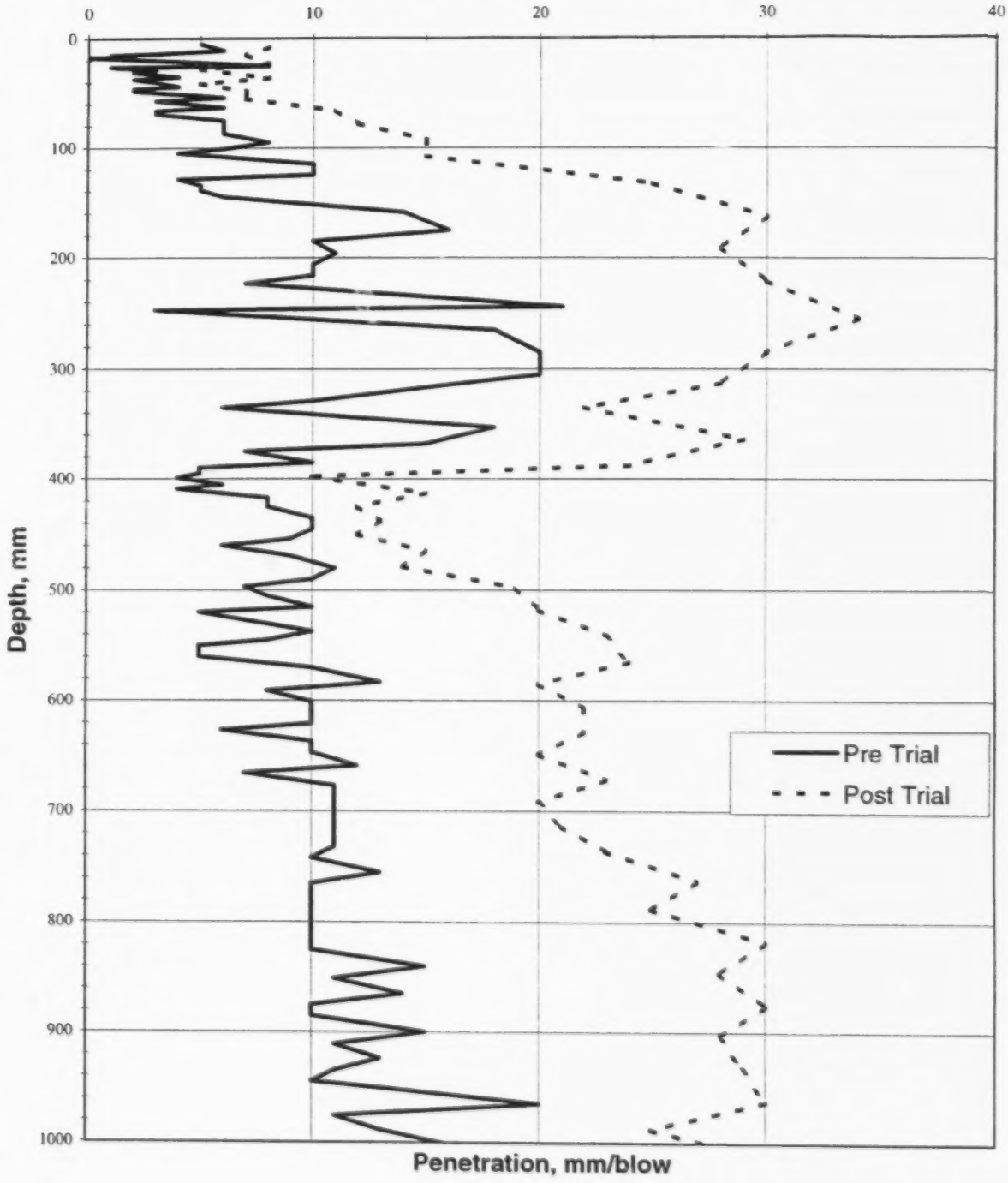

Figure C-13
Test Road 202, Station 2+800 NBL

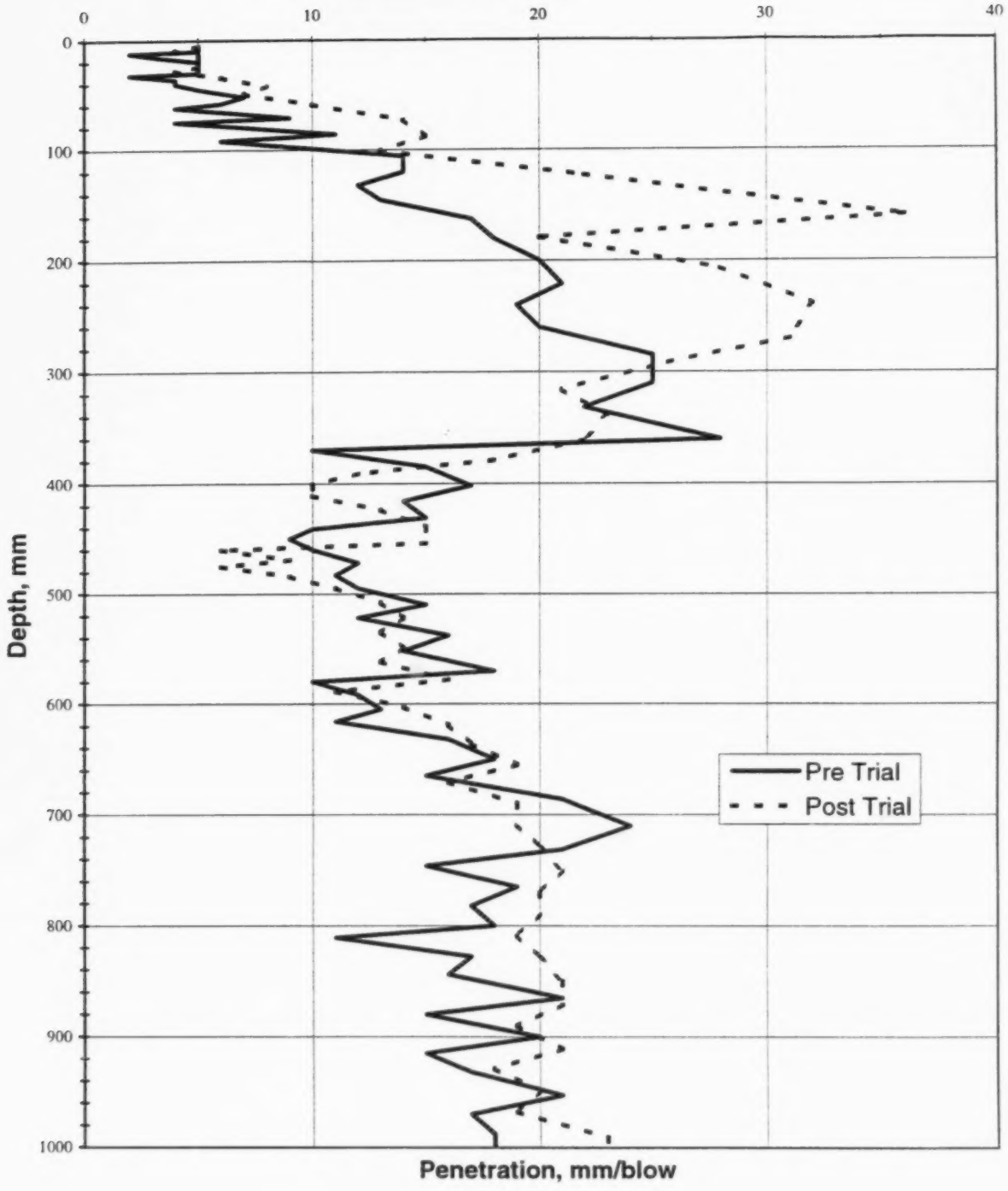

Figure C-14
Test Road 202, Station 2+800 SBL

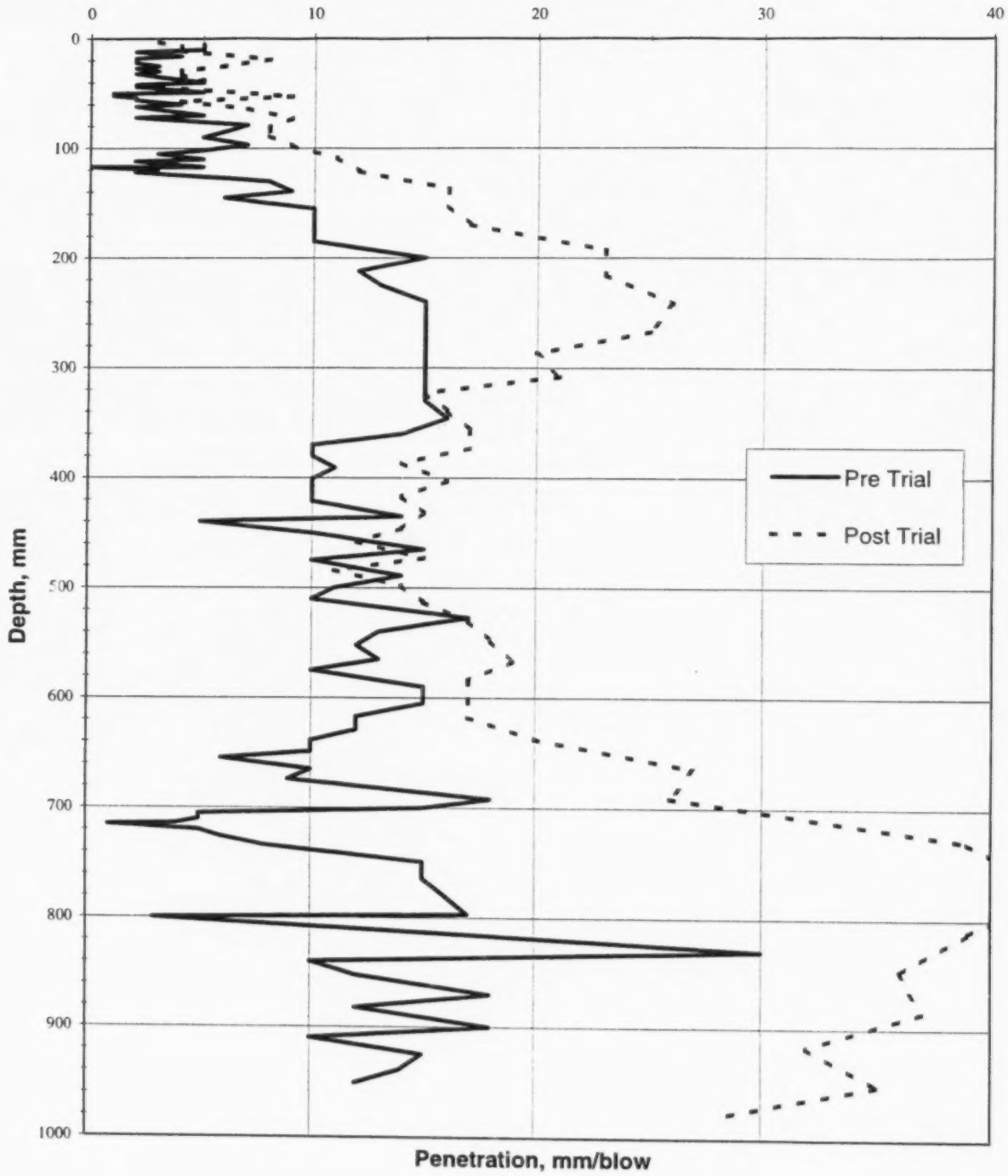

Figure C-15
Test Road 202, Station 3+600 NBL

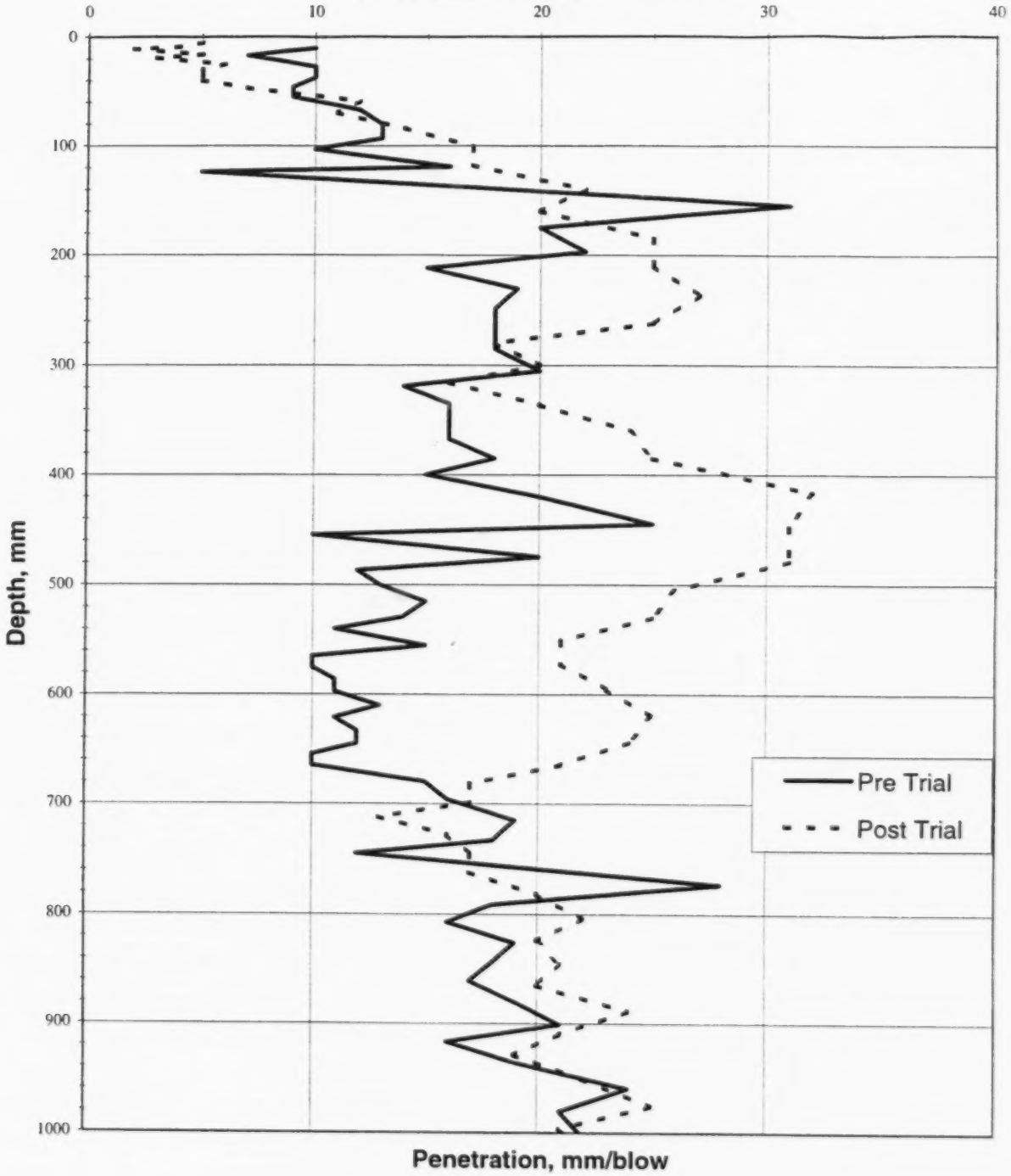

Figure C-16
Test Road 202, Station 3+600 SBL

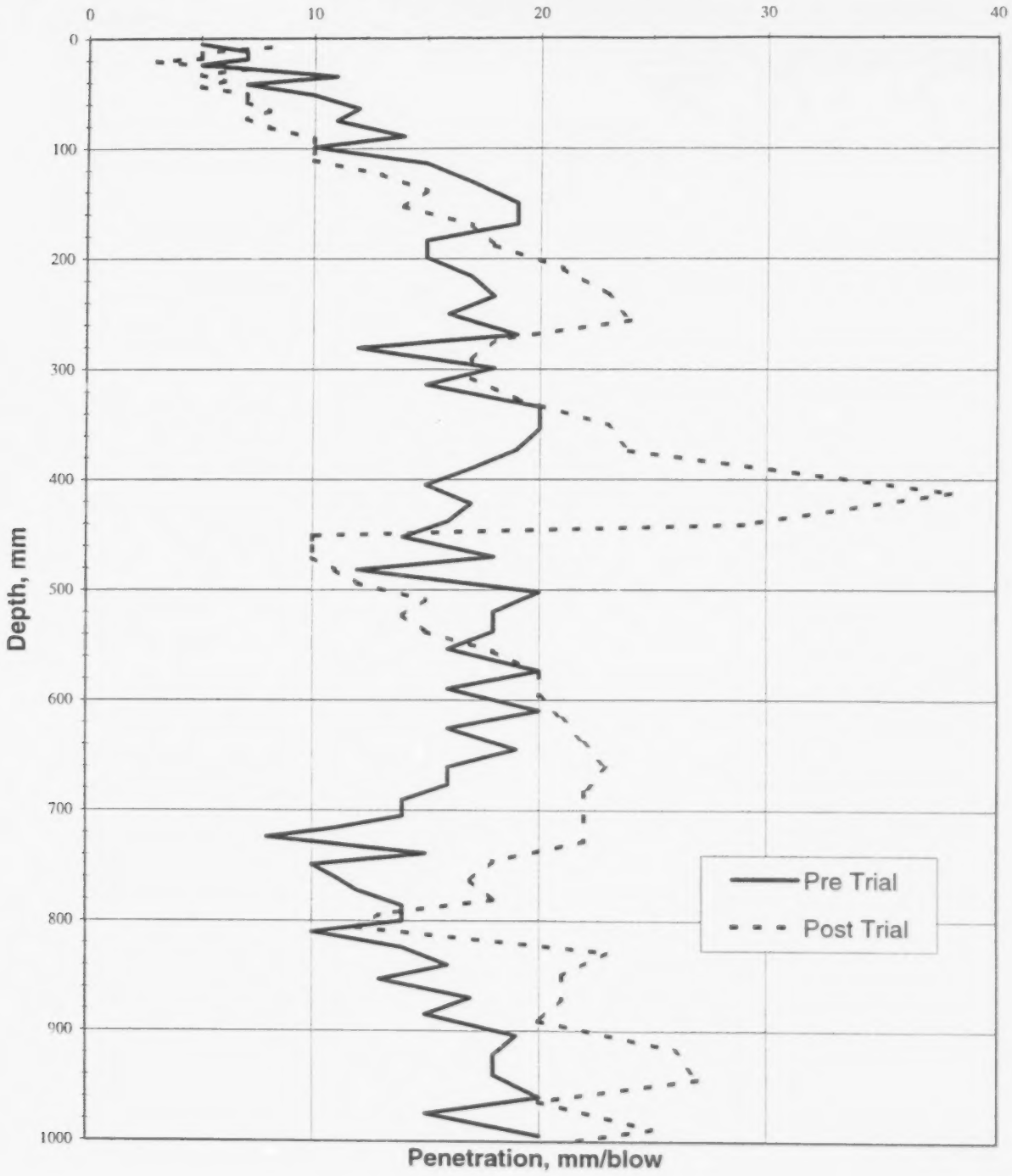

Figure C-17
Test Road 202, Station 4+400 NBL

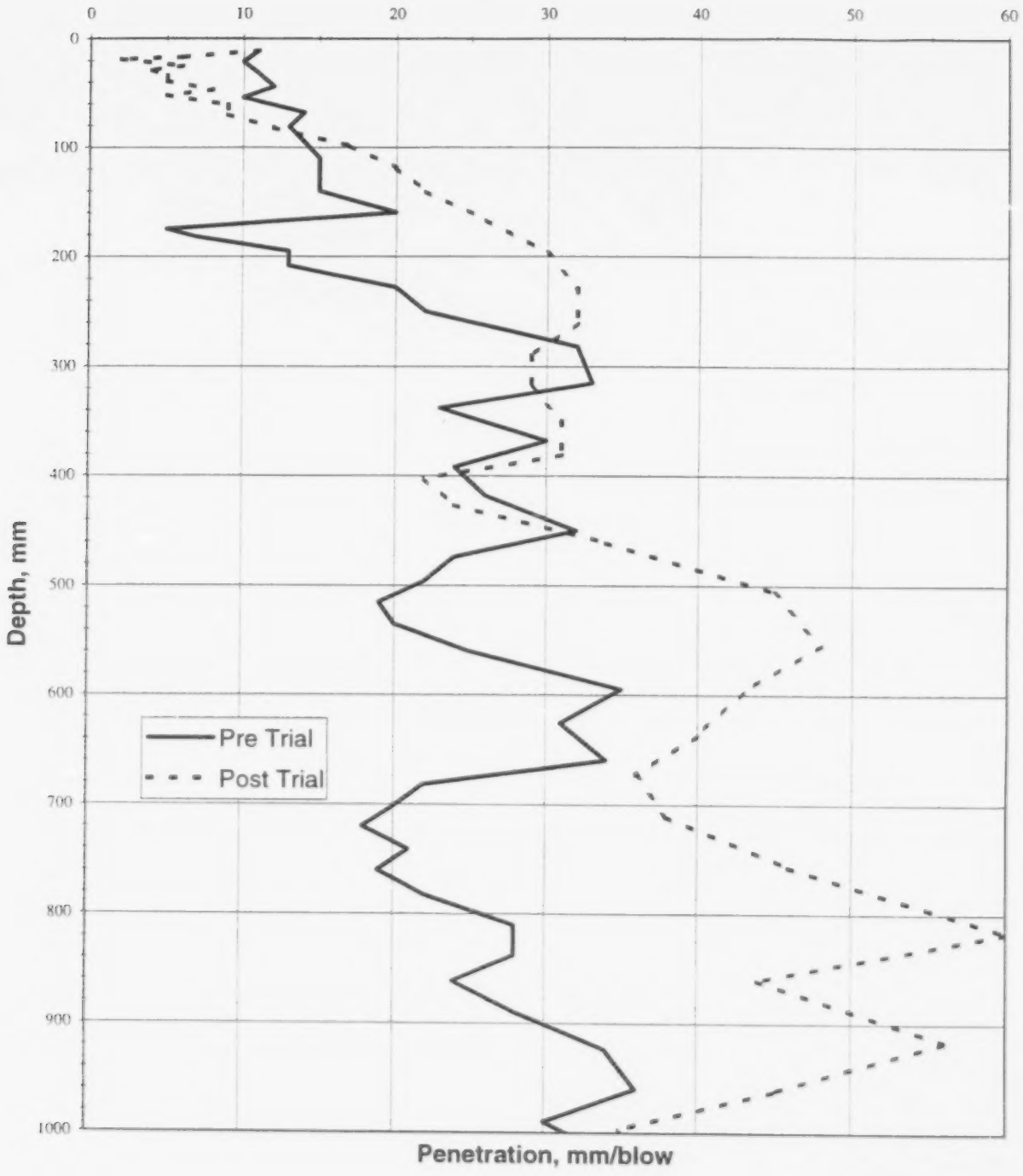

Figure C-18
Test Road 202, Station 4+400 SBL

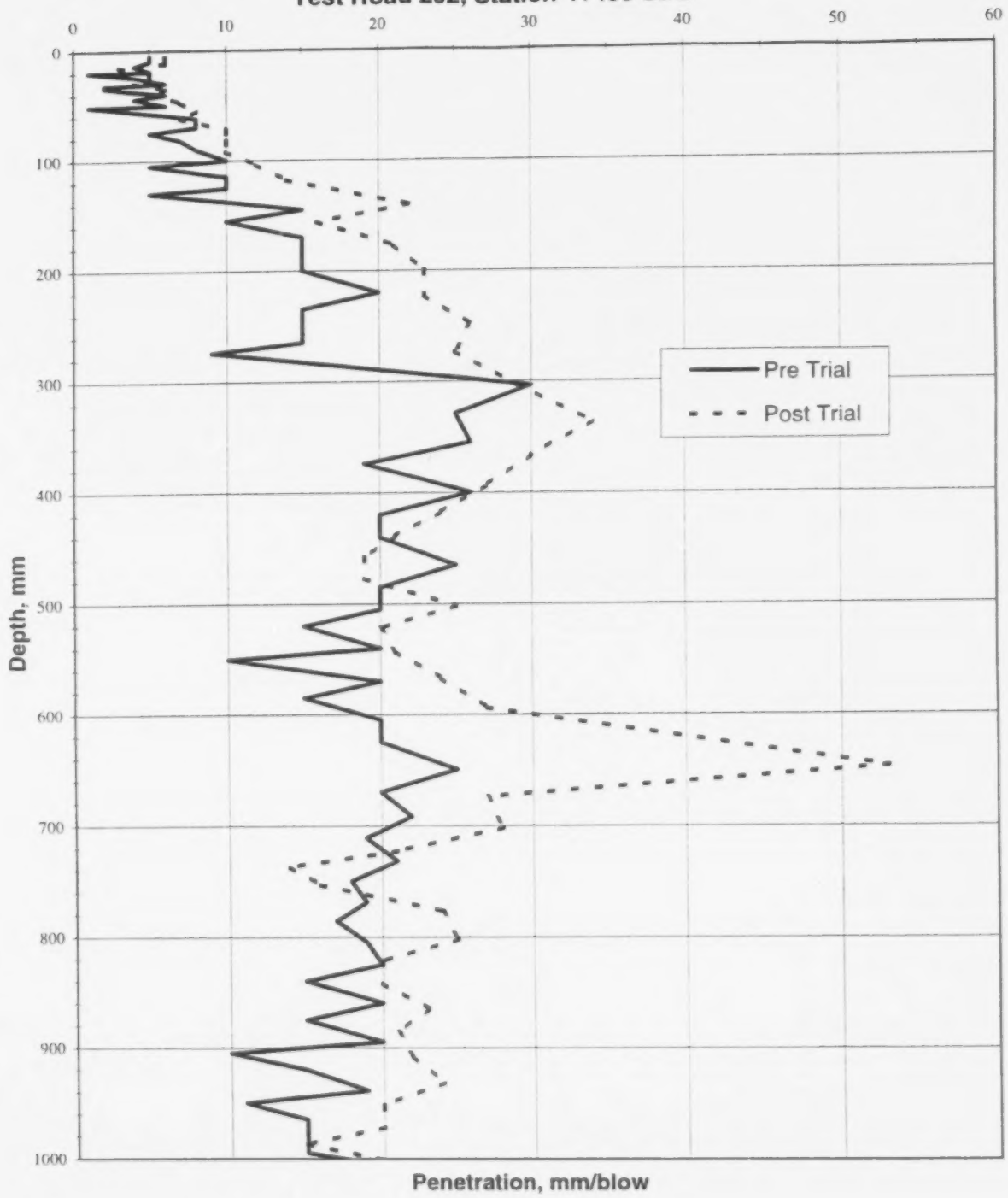

Figure C-19
Test Road 202, Station 2+797 NBL

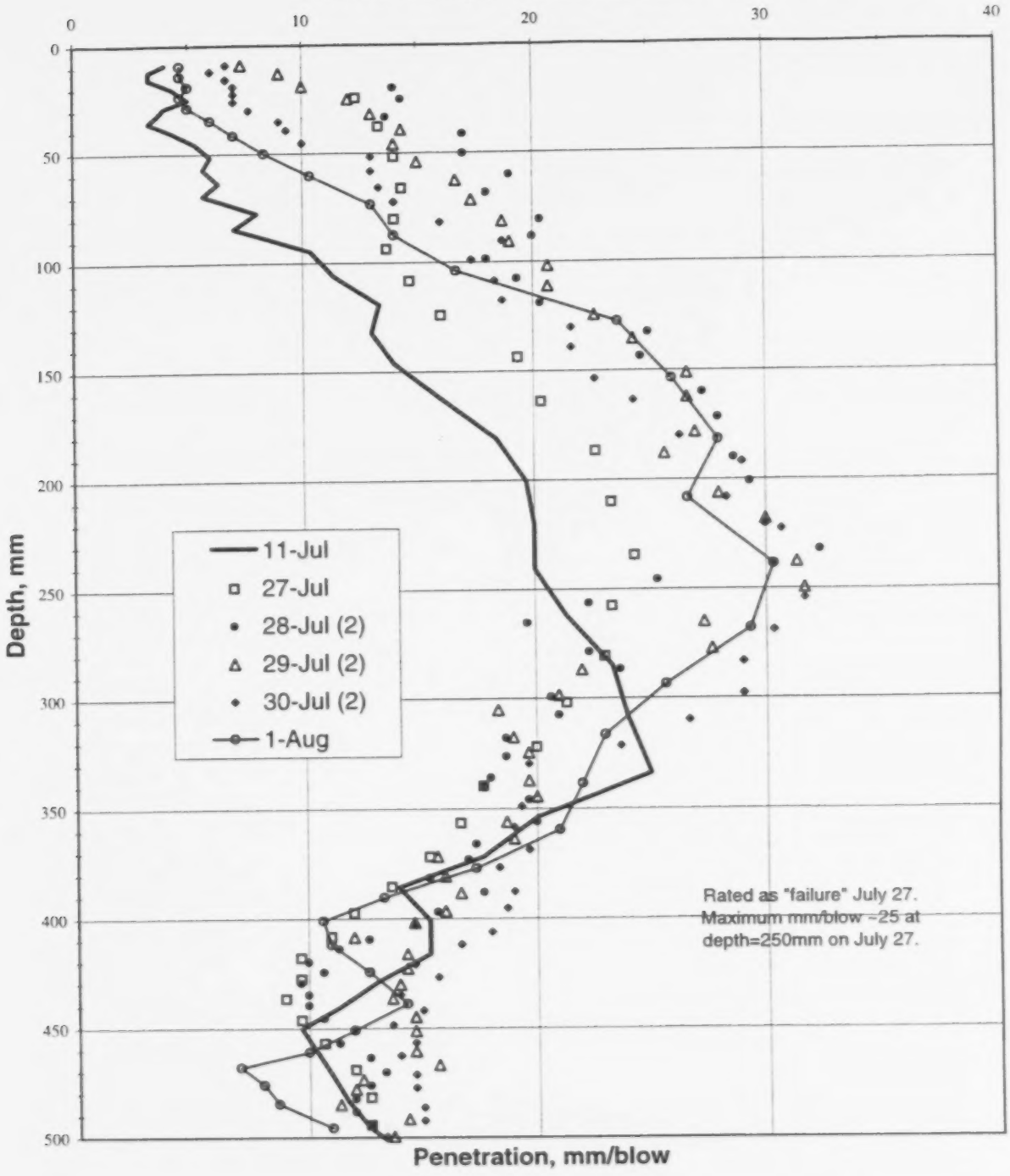

Figure C-20
Test Road 202, Station 2+797 SBL

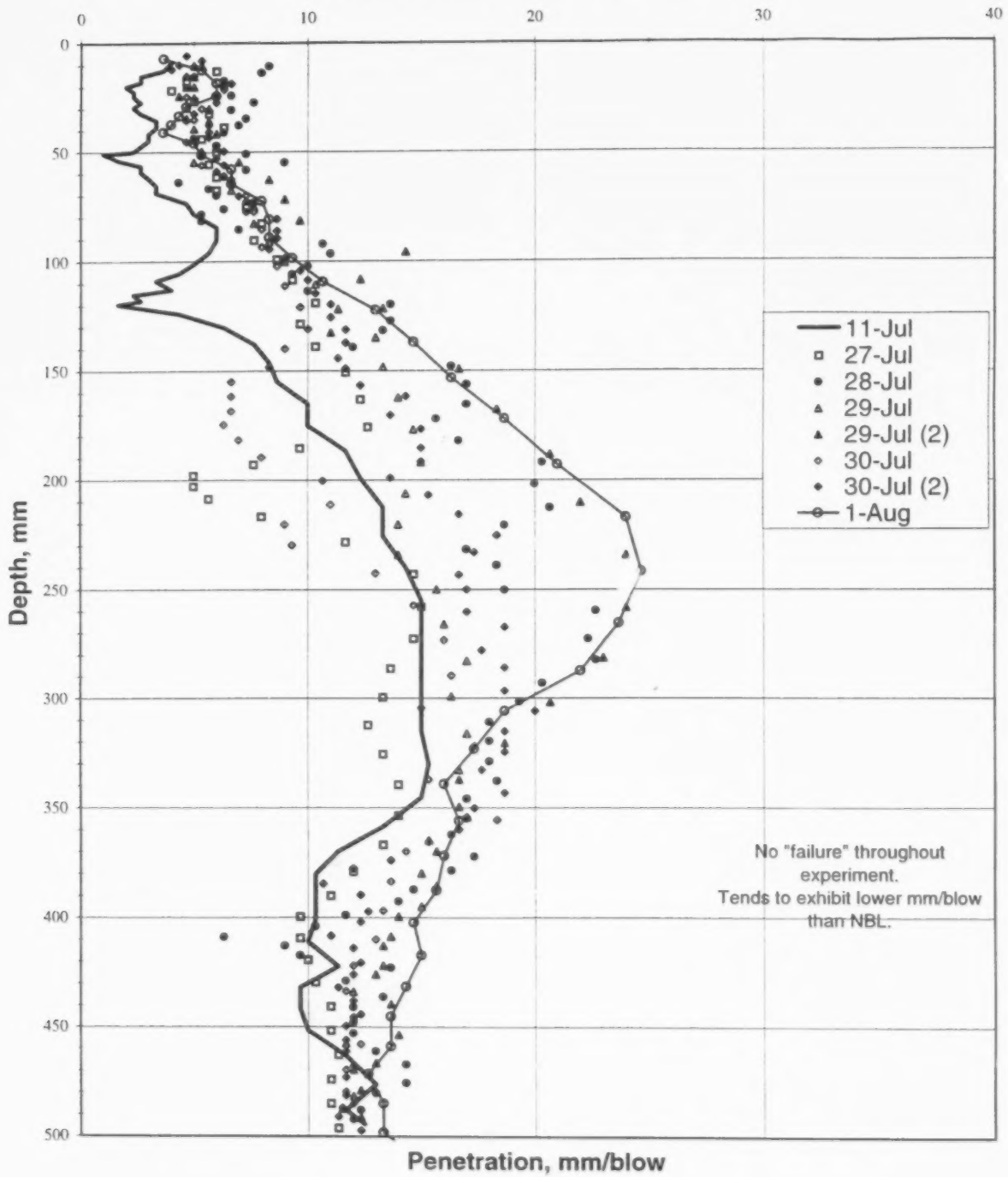

Figure C-21
Test Road 202, Station 3+998 NBL

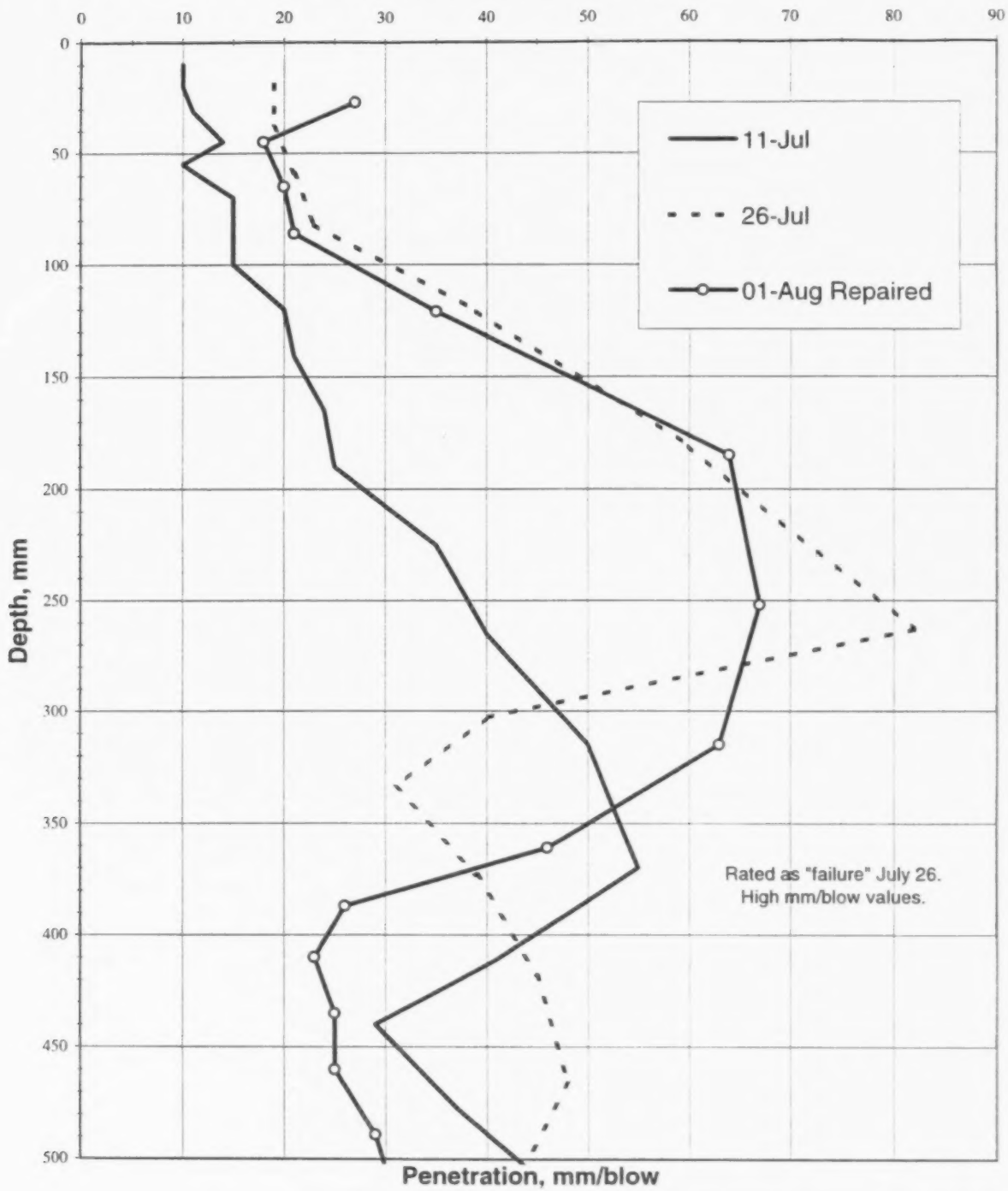

Figure C-22
Test Road 202, Station 3+998 SBL

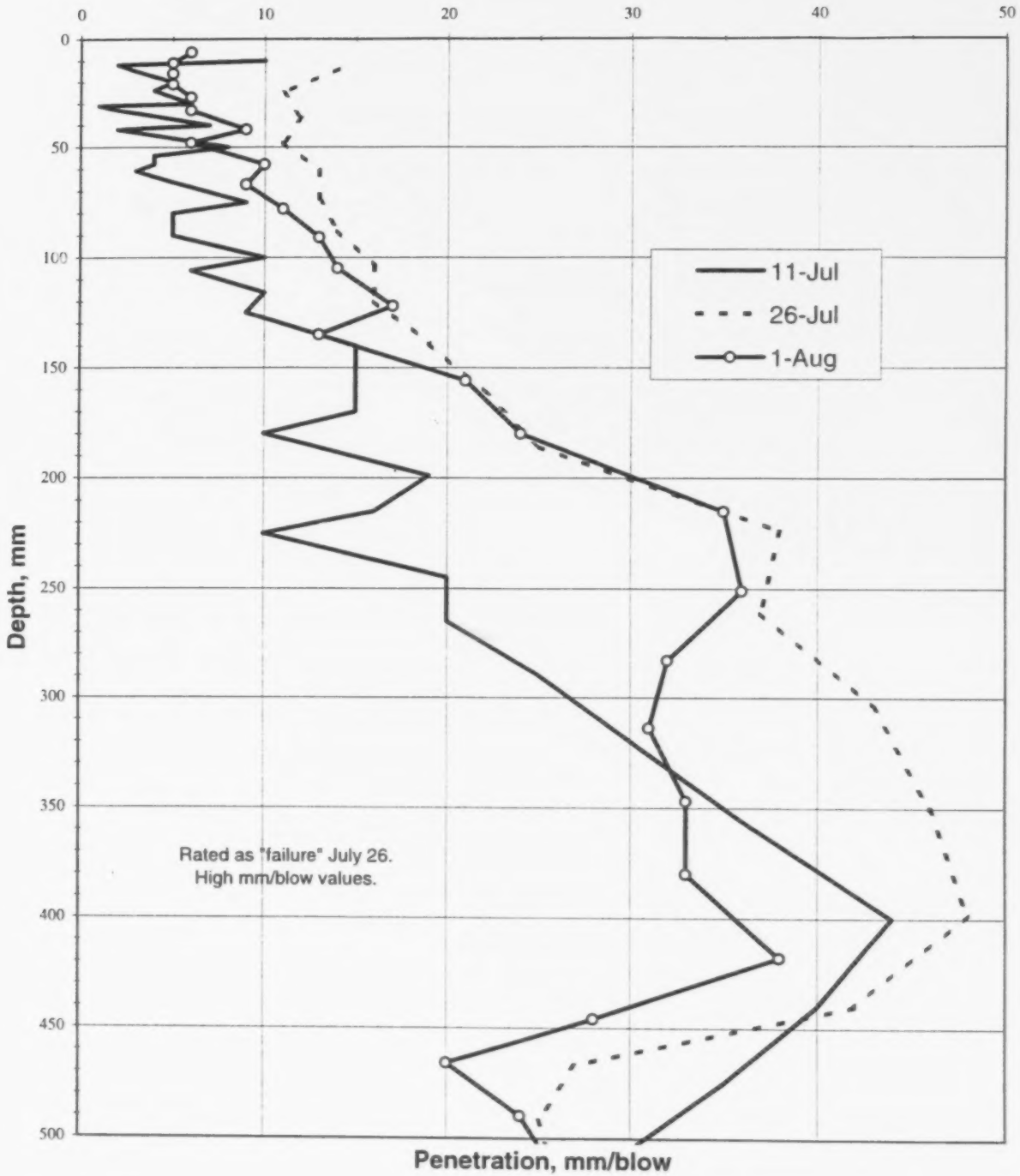

Figure C-23
Test Road 202, Station 4+977 NBL

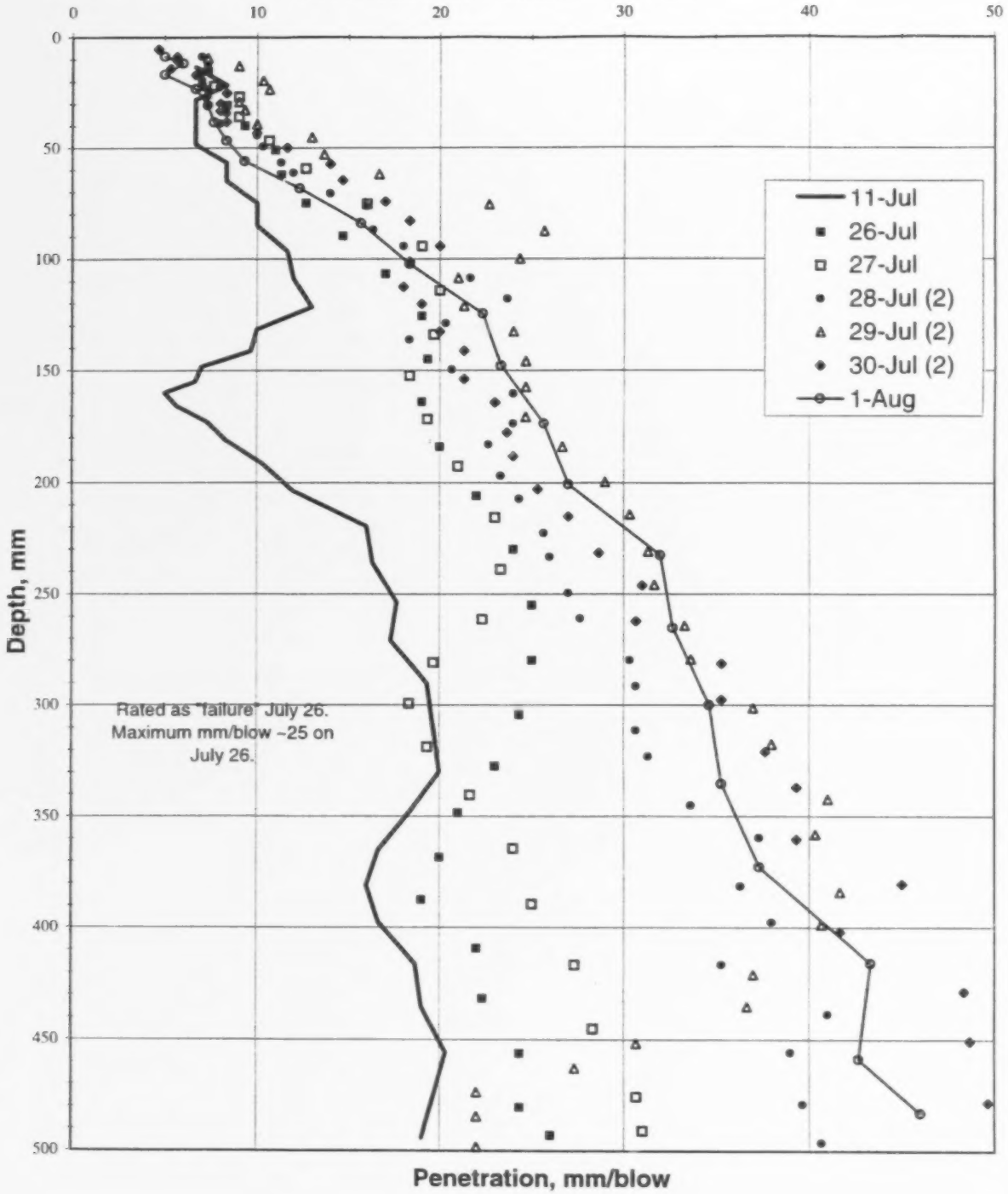

Figure C-24
Test Road 202, Station 4+977 SBL

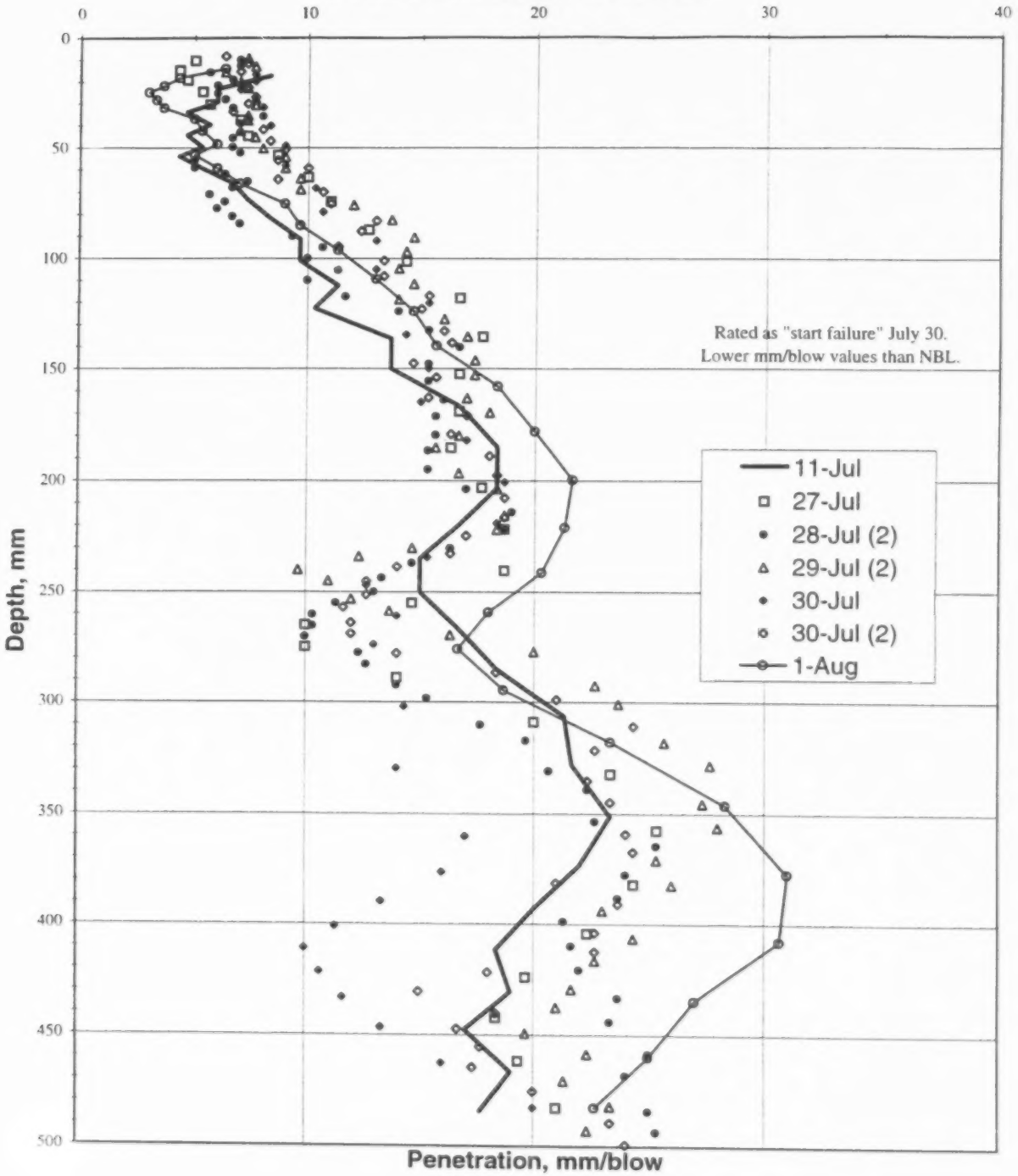

Figure C-25
Test Road 202, Station 5+198 NBL

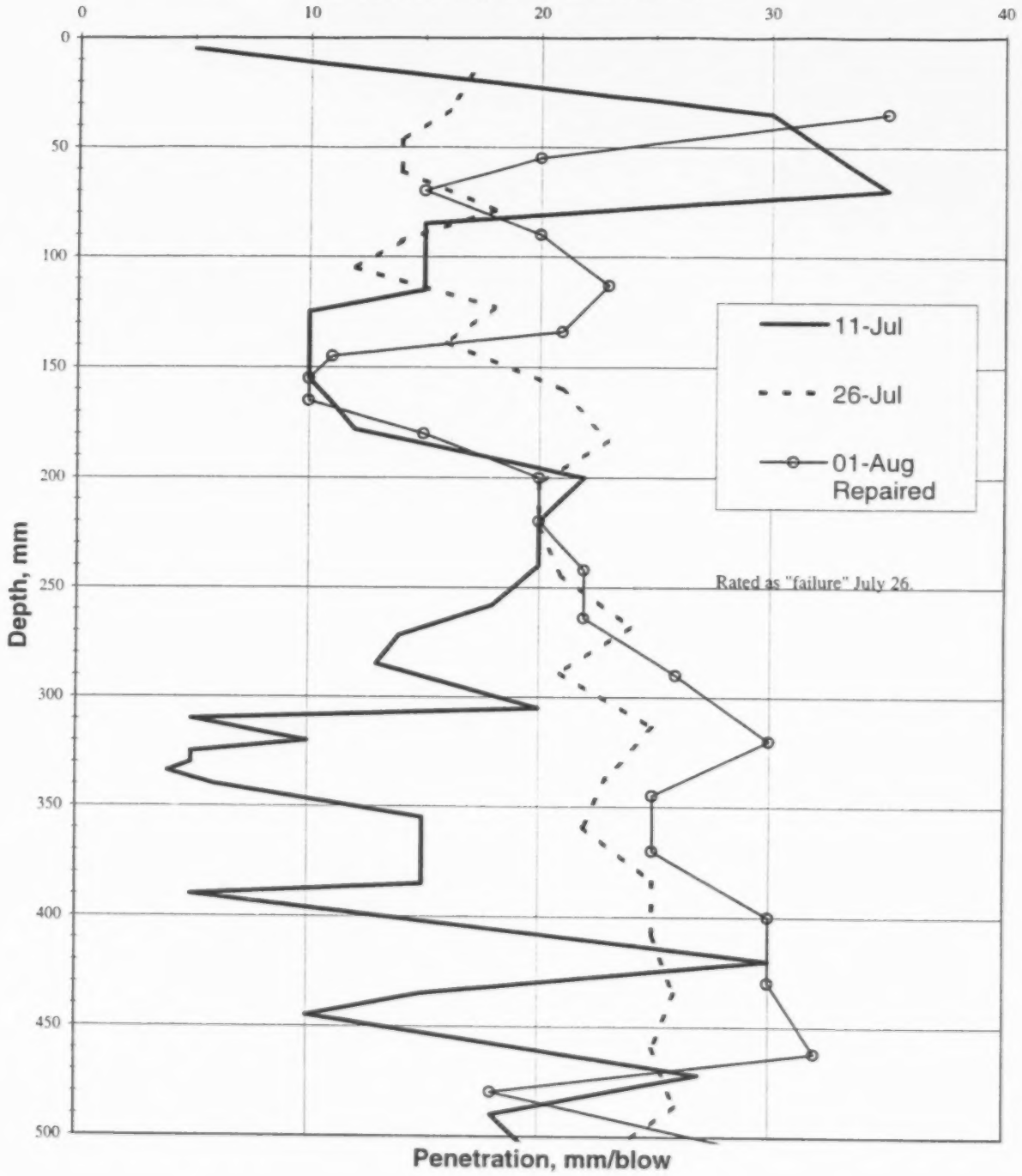

Figure C-26
Test Road 202, Station 5+198 SBL

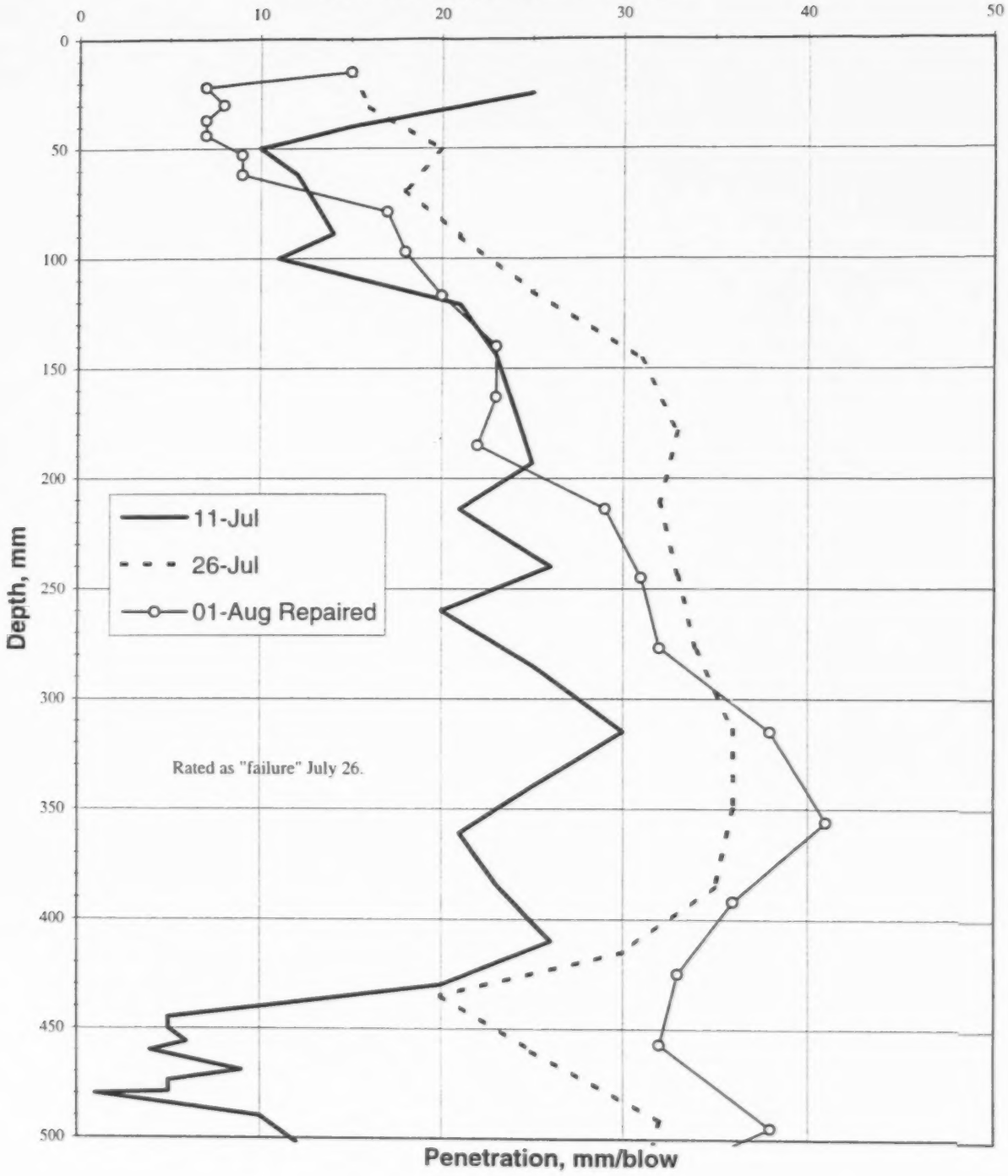

Figure C-27
Test Road 202, Station 5+398 NBL

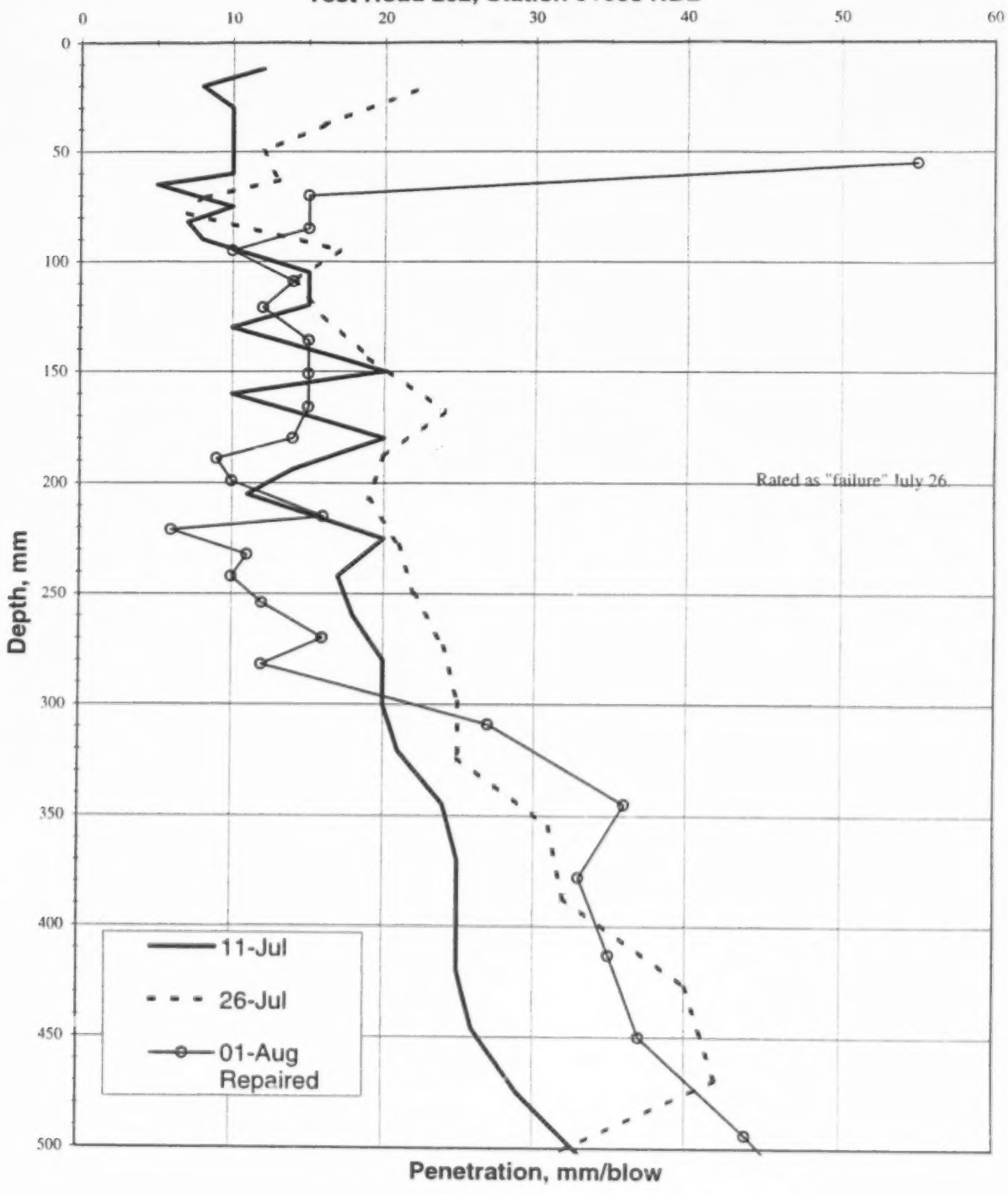

Figure C-28
Test Road 202, Station 5+398 SBL

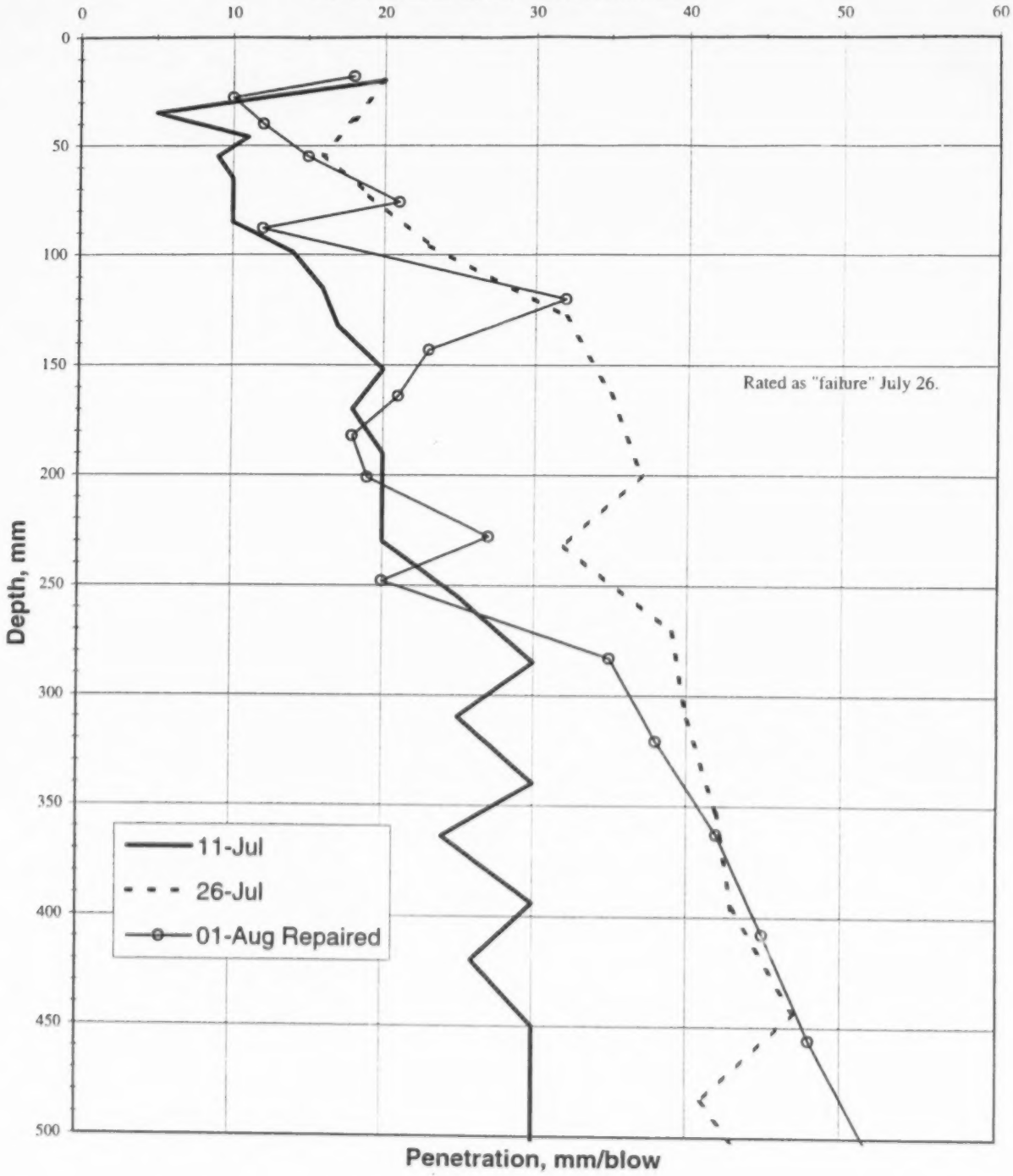

Figure C-29
Test Road 202, Station 6+197 NBL

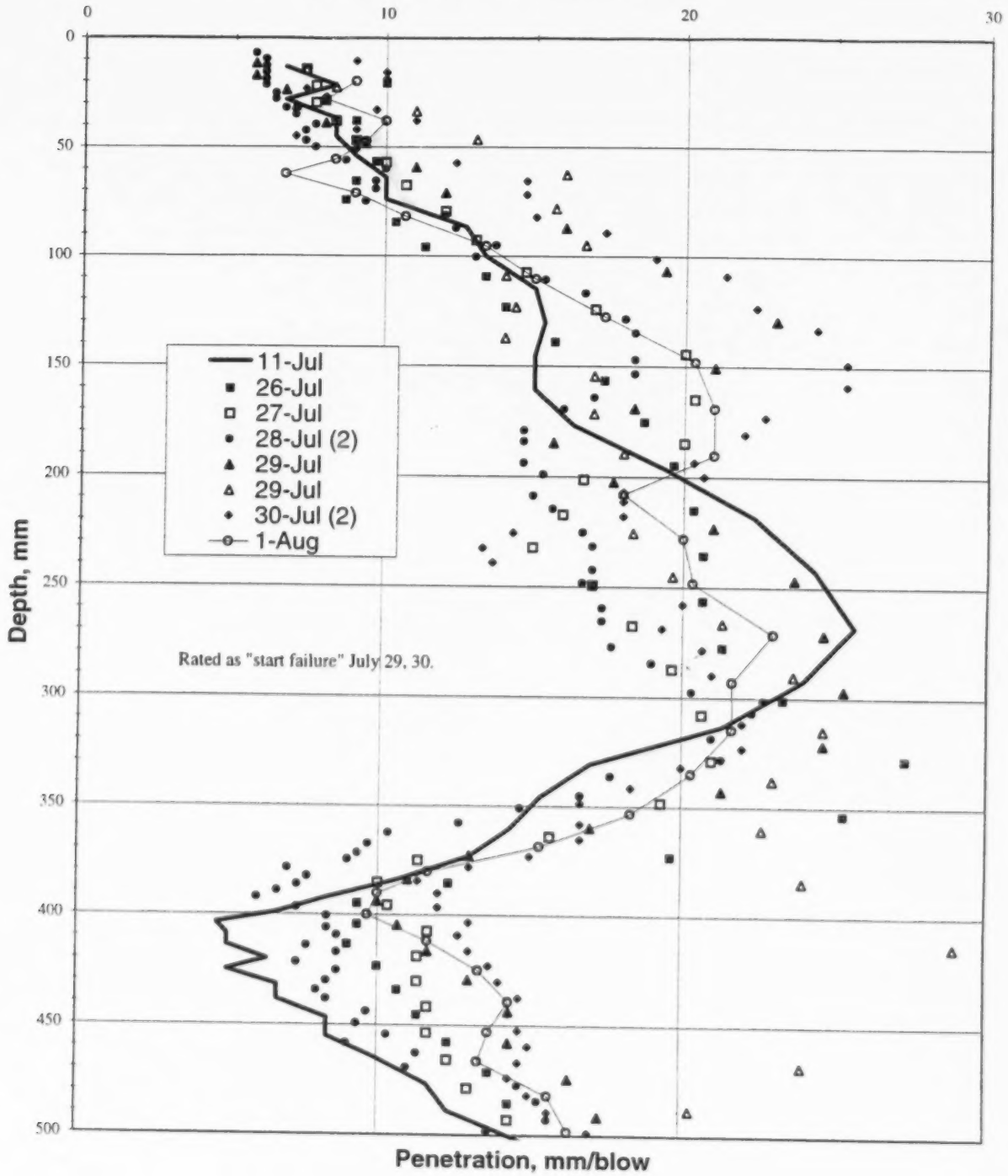
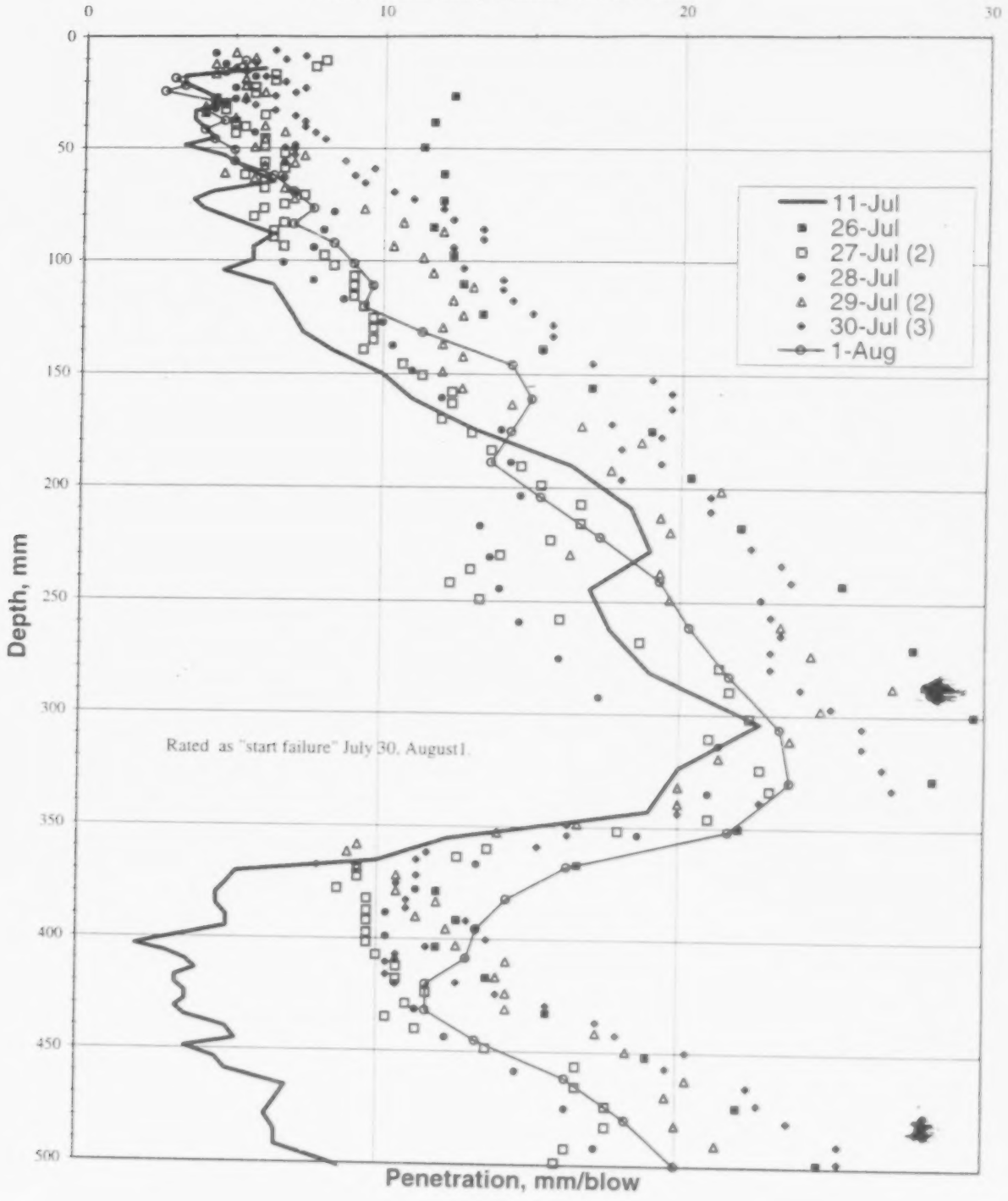
Figure C-30
Test Road 202, Station 6+197 SBL